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Assistant Commissioner for Patents  
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Sir:

Transmitted herewith for filing is the patent application of

Inventor(s): MISAWA, Takeshi

For: SOLID-STATE IMAGE PICKUP APPARATUS WITH FAST PHOTOMETRY  
WITH PIXELS INCREASED, AND SIGNAL READING OUT METHOD  
THEREFOR

Enclosed are:

X A specification consisting of 42 pages

X 19 sheet(s) of Formal drawings

X An assignment of the invention

X Certified copy of Priority Document(s)

X Executed Declaration X Original      Photocopy

     A verified statement to establish small entity status under 37  
CFR 1.9 and 37 CFR 1.27

     Preliminary Amendment

X Information Disclosure Statement, PTO-1449 and reference(s)

Other \_\_\_\_\_

The filing fee has been calculated as shown below:

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TOTAL CLAIMS	17 - 20 =	0	x18 = \$	0.00	or	x 9 = \$	0.00
INDEPENDENT	2 - 3 =	0	x78 = \$	0.00	or	x 39 = \$	0.00
MULTIPLE DEPENDENT CLAIM PRESENTED <u>no</u>				+260 = \$	or	+130 = \$	0.00
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Respectfully submitted,

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1 SOLID-STATE IMAGE PICKUP APPARATUS WITH FAST PHOTOMETRY  
WITH PIXELS INCREASED, AND SIGNAL READING OUT METHOD  
THEREFOR

5 **BACKGROUND OF THE INVENTION**

**Field of the Invention**

The present invention relates to a solid-state image pickup  
apparatus with fast photometry with pixels increased and a  
signal reading out method therefor. More particularly, the  
10 invention relates to a solid-state image pickup apparatus,  
which includes an array of photosensitive cells integrated  
in higher density and arranged obliquely adjacent to each other,  
that is, in the co-called honeycomb structure having the lines  
or rows of cells offset from each other by a length equal to  
15 the half of the pitch of the cells in line or row, to accomplish  
an increased resolution, and which is advantageously applicable  
to an electronic still camera, an image input apparatus and  
the like.

20 **Description of the Background Art**

With reference to a solid-state image pickup apparatus  
taking the so-called honeycomb arrangement, various proposals  
have been disclosed in, for example, Japanese patent publication  
No. 31231/1992, and Japanese patent laid-open Nos. 77450/1994  
25 and 136391/1998.

In the apparatus disclosed in Japanese patent publication  
No.31231/1992, first electrodes meander along photosensitive  
cells which are arranged in the offset manner, so as to form  
30 a wavy shape pattern, and second electrodes are formed in  
another wavy pattern opposite in phase to the former. Other  
photosensitive cells are arranged in a region where the first  
and second electrodes separate so as to enable a signal to

1 be read out from each cells via means for selectively coupling  
with the second electrodes, in response to an enable signal  
supplied to the first electrode, thus further increasing the  
resolution and the sensitivity of the solid-state image pickup  
5 apparatus from conventional. In the publication, the  
photosensitive cells is exemplified as formed octagonal.

In Japanese patent laid-open publication No. 77450/1994,  
the shape of photosensitive cells is formed as a square which  
10 is one of diamond shapes, and each side thereof forms an angle  
of 45 degrees in a vertical direction, so that its aperture  
ratio is made to be high, thus miniaturizing the solid-state  
image pickup apparatus. Particularly, by adopting a honeycomb  
arrangement, an increase in a vertical resolution is achieved.  
15 Moreover, a micro-lens is disposed on each photosensitive cell,  
thus increasing a light receiving efficiency.

In Japanese patent laid-open publication No. 136391/1998,  
meandering charge transfer devices of two lines are arranged  
20 between photoelectric conversion devices in a column direction,  
which are disposed so as to be adjacent to each other in the  
same row and relatively shifted by approximately the half of  
the interval between themselves in the adjacent rows, and  
the charge transfer devices are used for transferring the charge  
25 from the photoelectric conversion devices obliquely adjacent  
to each other. A spurious signal aliasing such as moiré is  
suppressed while achieving a high-density integration of the  
photoelectric conversion devices and an increase in a  
photoelectric conversion efficiency.

30 In this case, color filter segments are arranged in the  
form of Bayer arrangement rotated by 45°. In this color filter  
arrangement, color G is arranged in an isotropic relation to  
color R/B in both row and column directions. Also, a honeycomb

1 stripe pattern is used, where the same number of color filter  
segments for colors R, G and B are uniformly arranged. In  
this case, the shape of the color filter segments are a regular  
hexagon and set in a relationship where the center distances  
5 between adjacent photosensitive cells are all equal.

In the foregoing Japanese patent publication No. 31231/1992  
and Japanese patent laid-open publication No. 77450/1994,  
attention is paid only to the structure of the device in aiming  
10 at a high-density integration. Moreover, in Japanese patent  
laid-open publication No. 136391/1998, descriptions for the  
structure and the shape of the device and the positional  
relation of the color filters are made. Then, descriptions  
of whole-pixel reading out using these relations are made.

15 By the way, it is apprehended that a high-density  
integration takes times for a reading out of signal charge  
obtained by a photoelectric conversion. For example, in a  
mode of controlling a light measurement or a photometry in  
20 which an automatic focus adjustment (AF) and an automatic  
exposure (AE) control are performed, there are demands for  
shortening a time required for reading out the signal charge  
and for finishing a preparation for an image pickup without  
delay. For photosensitive cells, the high-density integration  
25 of the image pickup devices and shortening of the time of the  
signal reading out are antinomic demand, which are contradictory  
to each other.

30 Particularly, when the signal is read out from the  
photosensitive cells adopting a honeycomb arrangement in the  
mode of controlling a light measurement, a breakthrough by  
a different method from conventional methods is needed.

In particular, to perform Automatic Exposure (AE) control

1 or Automatic White Balance (AWB) adjustment, information on  
all colors is necessary, and single-color reading out as in  
the case of Automatic Focus adjustment (AF) is useless. High-  
speed signal reading out timed with a drive signal is desired  
5 when the image capturing with the AE and AWB controls is  
performed.

#### SUMMARY OF THE INVENTION

10 It is therefore an object of the present invention to  
provide a solid-state image pickup apparatus capable of  
performing, for instance, AE control faster than conventional  
signal reading out by means of an image signal containing all  
colors used for color separation in photosensitive cells  
arranged in a honeycomb-like structure, and to provide a signal  
15 reading out method therefor.

20 In a solid-state image pickup apparatus capable of  
performing, for instance, AE control by means of an image signal  
containing all colors used for color separation in  
photosensitive cells arranged in a honeycomb-like structure,  
and signal reading out method therefor, a digital still camera  
supplies a signal in a mode set by a mode setting section to  
a system control section. Upon receiving the signal, the system  
control section controls a drive signal generation section  
25 to generate a drive signal. Incident lights are supplied onto  
an image pickup section through a color separation filter having  
filter segments of identical colors arranged in a column  
direction. The image pickup section photoelectrically converts  
the lights incident to the respective photosensitive cells.  
30 A drive signal generated by the drive signal generation section  
according to the specified mode is supplied to a signal reading  
out gate, so that an transfer for the signal charges is  
performed. In this case, signals for all the colors are read  
out in response to the drive signal in compliance with the

1 color filter arrangement of the color separation filters.  
The signals read out are used by AF and AE adjustment sections  
for appropriate controls.

5 Accordingly, in an application in which much more  
photosensitive cells are integrated, time required for signal  
reading out can be shortened without any color limitations.  
Thus, the solid-state image pickup apparatus is advantageously  
applicable to, for instance, AE or AWB adjustment control which  
10 requires a reduction in signal reading out time.

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15 A signal reading out method of the present invention  
includes the steps of selecting a whole-pixel reading out mode  
of reading out signal charges from all the pixels or a thinning  
reading out mode for reading out signal charges after thinning,  
generating a drive signal for reading out the signal charges  
according to the selected mode, selecting a destination to  
which this drive signal is supplied, and then supplying the  
signal to the destination. An incident light is separated  
20 into at least three colors, and the incident light separated  
in the color in the color separation step is received by each  
of a plurality of photosensitive cells.

25 After this image pickup step, especially in the thinning  
reading out mode, only signal charges generated by the  
photosensitive cells of a line to be read out among the  
plurality of photosensitive cells are field-shifted in response  
to the drive signal. Thereafter, signal charges are transferred  
in a column direction in compliance with the arrangement of  
30 color filters for color separation. Then, after the signal  
charges are shifted in line, the signal charges "EMPTY" of  
column where neither pixel mixing nor signal reading out occurs  
are synthesized to combine signals read out from a plurality  
of the photosensitive cells. By transferring the line-shifted

1 signal charges in a horizontal direction, compared with signal  
reading out in the whole-pixel reading out mode, reading out  
of the signal charges of all the colors can be completed within  
a very short time.

#### 5 BRIEF DESCRIPTION OF THE DRAWINGS

The objects and features of the present invention will  
become more apparent from consideration of the following  
detailed description taken in conjunction with the accompanying  
10 drawings in which:

FIG. 1 shows a way of connecting FIGS. 1A and 1B with  
each other;

FIGS. 1A and 1B are schematic block diagrams, which show  
in contribution an exemplified constitution of a solid-state  
15 image pickup apparatus of the present invention applied to  
a digital still camera;

FIG. 2 is a schematic plan view useful understanding the  
relationship between the vertical transfer paths and  
photosensitive cells arranged in the form of a honeycomb in  
the image pickup device of FIG. 1A, when viewing from its light  
20 incident side;

FIG. 3 is a schematic plan view showing an arrangement  
of color separating filters adopting a honeycomb type G square  
lattice RB complete checkered pattern, in which the color  
separation filters are arranged integrally with each other  
25 on the light incident side of the image pickup device shown  
in FIG. 1A;

FIG. 4 is a schematic plan view showing the connections  
of the photosensitive cells, signal reading out gates, transfer  
devices on the vertical transfer paths and horizontal transfer  
paths, and drive signals supplied to them;  
30

FIG. 5 is a timing chart showing a vertical synchronous  
signal, a vertical timing signal and a transfer gate signal  
when a whole-pixel reading out is performed by the drive signal



1 generator shown in FIG. 1B;

FIG. 6 is a timing chart showing the vertical synchronous signal, the vertical timing signal and the transfer gate signal with the leading edge portion of the vertical synchronous signal of FIG. 5 is depicted in an enlarged scale;

FIG. 7 is a timing chart illustrating the vertical synchronous signal, a horizontal synchronous signal, the vertical timing signal, the transfer gate signal, a drive signal and a potential generated by the drive signal in the vicinity of a leading edge portion of the horizontal synchronous signal shown in FIG. 6 in an enlarged scale;

FIG. 8 is a timing chart useful for understanding the phase relationship between the vertical timing signals used for generating signals of a four-phase drive in the image pickup device shown in FIG. 1A;

FIG. 9 is a timing chart depicting the vertical synchronous signal, the horizontal synchronous signal, the vertical timing signal and the transfer gate signal, which are generated by a signal generator when signal charge only for a color G is read out in the image pickup device shown in FIG. 1A in a mode of controlling a light measurement;

FIG. 10 is a schematic plan view useful for understanding the positional relationship of the photosensitive cells from some of which signal charges are actually read out and from the others of which no signal charges are read out in response to the supplied transfer gate signals shown in FIG. 9;

FIGS. 11A, 11B and 11C are schematic plan views, which illustrate the states of field shift, vertical transfer and horizontal transfer, respectively, in signal-charge reading out operated in response to a drive signal supplied based on the signal of FIG. 9 generated by the signal generator;

FIGS. 12A and 12B schematically illustrate vertical and horizontal transfers, respectively, carried out after the signal reading out of FIG. 11C;

1           FIGS. 13A and 13B schematically illustrate the states  
of vertical and horizontal transfers in a process improved  
from the thinning of FIGS. 11A - 12B;

5           FIG. 14 is a schematic view illustrating a state continuing  
from the improved thinning process of FIGS. 13A and 13B;

          FIG. 15 is a timing chart useful for understanding a timing  
relationship when  $1/4$  thinning is performed in a vertical  
direction in the image pickup device of the digital still camera  
in the photometry control mode;

10          FIG. 16 is a timing chart useful for understanding the  
relationship between a vertical synchronous signal, vertical  
timing signals and transfer gate signals in the vicinity of  
the positive-going edge of the vertical synchronous signal  
of FIG. 15 in an enlarged scale;

15          FIG. 17 is a timing chart useful for understanding  
relationship between the vertical synchronous signal, the  
horizontal synchronous signal, the vertical timing signals  
and the transfer gate signals in the vicinity of the positive-  
going edge of the horizontal synchronous signal of FIG. 16  
20 in an enlarged scale;

          FIGS. 18A, 18B and 18C schematically illustrate the  
transferring processes of the  $1/4$  thinning in a vertical  
direction shown in FIG. 15 and the improved type of thinning  
( $1/2$ ) shown in FIGS. 13A and 13B;

25          FIGS. 19A and 19B are schematic views useful for  
understanding the flow of signal charges in the image pickup  
device after the transfer of FIG. 18C;

          FIGS. 20A to 20D are schematic views useful for  
understanding the transferring process of the  $1/4$  thinning  
30 in a vertical direction shown in FIG. 15 and the improved type  
of thinning ( $1/4$ ) including pixel mixing carried out twice;  
and

          FIGS. 21A, 21B and 21C are a schematic views useful for  
understanding the flow of signal charges in the image pickup

1 device after the transfer of FIG. 20D.

#### **DESCRIPTION OF THE PREFERRED EMBODIMENTS**

5 Next, description will be made of a preferred embodiment of a solid-state image pickup apparatus in accordance with the present invention with reference to the accompanying drawings.

10 A solid-state image pickup apparatus of the present invention includes an image pickup device having an array of photosensitive cells integrated in the form of honeycomb arrangement, and requires a shortened period of time for reading out a signal than that for the whole-pixel scheme in order to achieve a high speed automatic control of AE and AWB by using all the colors of the primary or complementary color filters, for example. A noteworthy feature of the solid-state image pickup apparatus is its capability of performing the automatic control as fast as conventional by reading out signals from specified photosensitive cells even in the honeycomb arrangement employed.

20 Description will now be made of a case where the solid-state image pickup apparatus of the present invention is applied to a digital still camera 10. Parts having no direct relations with the present invention are not shown, and description thereof will be omitted. Signals are designated with the same reference numerals as connecting lines on which the signals are conveyed.

30 As shown in FIGS. 1A and 1B, the digital still camera 10 includes an image pickup system 10A, a signal processing system 10B, a drive signal generation section 10C, a signal output system 10D, a mode setting section 10E and a system control 12.

1           The image pickup system 10B includes an optical lens 102,  
an image pickup device 104, an AF control 106 having a focusing  
mechanism and an AE control 108 having an aperture mechanism.  
In addition to these elements, although not shown, to completely  
5       shut off an incident light, a shutter mechanism may be included  
in an incident light side of the image pickup device 104.  
The optical lens 102 is an optical system for focusing the  
incident light from an object field on a photosensitive array  
of the image pickup device 104.

10           The image pickup device 104 includes an array of  
photosensitive cells 104a arranged two-dimensionally in a  
honeycomb-like manner in row and column directions such that  
the photosensitive cells 104a for performing photoelectric  
15       conversion for supplied incident lights form a light receiving  
plane (see FIG. 2). In the honeycomb-like structure, the  
respective photosensitive cells 104a are shifted or offset  
from other photosensitive cells obliquely adjacent thereto  
by a length equal to the half of the pitch thereof in the row  
20       and column directions. The honeycomb-like structure does not  
mean the shape of the photosensitive cell. It should be noted  
that the pitch means, for example, the distance between the  
centers of the adjacent two photosensitive cells in the row  
or column direction. In the image pickup device 104, on the  
25       surface of the photosensitive cells 104a, a single plate of  
color separation filter CF is formed integrally to separate  
colors of the incident light, which correspond to the respective  
photosensitive cells 104a. The arrangement of the color  
separation filter CF causes an incident light to be separated  
30       in color to have the respective color attributes of primary  
colors RGB to be received by the respective photosensitive  
cells 104a.

As shown in FIG. 3, because of the integral structure,

1 this relationship of colors is represented by symbols R, G  
and B indicating colors in the respective photosensitive cell  
104a. The same color filter segment R, G or B of FIG. 3 is  
aligned in the vertical direction as in the stripe form. Thus,  
5 this color filter arrangement is called a honeycomb type stripe  
pattern. The image pickup device 104 outputs an image signal  
10a to the signal processing system 10B.

10 In the illustrative embodiment shown and described above,  
the single plate of color separation filter CF is of the  
honeycomb type primary color RGB columnar striped pattern  
composed of the RGB filter segments. The present invention  
is however not restricted to the specific type of color filter  
described above but advantageously applicable to other filter  
15 systems of complementary colors, such as the honeycomb type  
three-color GYeCy columnar striped pattern in which for the  
color filter segments R, G and B of the honeycomb type primary  
color RGB columnar striped pattern, replaced are the color  
filter segments of Yellow Ye, green G and cyan Cy, respectively,  
20 and the honeycomb type three-color, Gray or W and YeCy columnar  
striped pattern in which for the color filter segments Ye,  
G and Cy of the honeycomb type three-color GYeCy columnar  
striped pattern, replaced are the color filter segments of  
yellow Ye, gray Gray or white W, and cyan Cy, respectively.

25

The constitution of the image pickup device 104 will be  
further described. The image pickup device 104 operates in  
response to a drive signal 122a output from the drive signal  
generation section 10C. Each of the photosensitive cells 104a  
30 is constituted by a charge coupled device (hereinafter referred  
to as CCD). As shown in FIG. 4, each of the photosensitive  
cells 104a is provided with a signal reading out gate or  
transfer gate 104b connected to a transfer device adjacent

1 thereto, specifically the vertical transfer device. The signal  
reading out device 104b is adapted to block the signal charge  
converted from the incident light from leaking. The signal  
5 reading out gates 104b transfer the signal charge from the  
photosensitive cells 104a to vertical transfer paths 104c in  
response to a field shift pulse supplied through the electrodes.  
The vertical transfer paths 104c transfer sequentially the  
signal charge read out in the column direction, that is, in  
10 the vertical direction. The signal charge is supplied to  
transfer devices in line direction, that is, horizontal transfer  
path 104d, through line shifting. In response to a drive  
signal, the horizontal transfer path 104d outputs this signal  
charge to the signal processing system 10B through an amplifier  
104e as described above.

15 Here, in each of the vertical transfer paths 104c, three  
transfer devices are disposed between adjacent two of the  
photosensitive cells 104a when viewing in the vertical direction  
(column direction). The four transfer devices, including the  
20 transfer devices connected to the associated signal reading  
out gates 104b, are used for transferring data of a pixel in  
one line. Thus, it is proved that four-phase drive signals  
are supplied as the drive signal for one line transfer. Each  
of the signal reading out gates 104b is disposed between one  
25 of the photosensitive cells 104a and one of the vertical  
transfer paths 104c.

30 Furthermore, since the arrangement of the photosensitive  
cells in the honeycomb-like manner is adopted in which the  
respective photosensitive cells are shifted from other  
photosensitive cells obliquely adjacent thereto by the half  
of pitch in the row and column directions, between adjacent  
two vertical transfer devices 104c in question, the signal  
reading out gates 104b are disposed in such a manner that one

1 is shifted from the other in the vertical direction by a  
distance equal to the two transfer devices of the vertical  
transfer paths 104b.

5 Specifically, when the relation in the arrangement between  
the two vertical transfer paths 104c is observed, the  
photosensitive device of color G corresponds in level to the  
vertical transfer device V1 in the vertical direction, the  
photosensitive device of color R to the vertical transfer device  
10 V3, the photosensitive device of color G to the vertical  
transfer device V5, and so on. The basic constitution of the  
image pickup device 104 has been described above. With such  
constitution, the whole-pixel reading out is performed normally.  
Thus, the signal charge of all of the photosensitive cells  
15 is read out at a time.

Returning to FIG. 1A, the AF control 106 adjusts the focal  
position of the optical lens 102 so as to be brought at the  
optimum position in accordance with information obtained by  
20 measuring the distance between an object and the camera 10  
by the focus adjustment mechanism (not specifically shown).  
At this time, an estimation of the information concerning the  
distance measurement and a control amount from the information  
concerning the distance measurement are processed by the system  
25 control 12. As a result, in response to the control signal  
12a supplied, the AF control 106 drives the focus adjustment  
mechanism in response to the drive signal 106a, so as to move  
the optical lens 102 along its optical axis in the direction  
of the arrow A.

30 Furthermore, the AE control 108 permits the aperture or  
iris of the aperture mechanism to be displaced under the control  
of an exposure control (not shown) provided in the system  
control 12 adapted to estimate the amount or intensity of the

1 measured light from the object field including the object,  
thus adjusting the amount of luminous flux incident onto the  
photosensitive array. The measurement of light is performed  
5 using a part of the image pickup signal. Also in this case,  
the exposure amount is calculated by the system control 12,  
based on the amount of measured light. The system control  
12 supplies to the AE control 108 the control signal 12a for  
use in controlling the aperture value and the shutter speed  
10 value so as to mate with the calculated exposure amount. The  
AE control 108 supplies a drive signal 108a to the aperture  
mechanism and the shutter mechanism in response to the control  
signal 12a so as to adjust those mechanisms to the aperture  
value and the shutter speed value. This adjustment will  
optimize the exposure.

15  
The signal processing system 10B of FIG. 1B comprises  
a pre-processor 110, an A/D converter 112, a signal processor  
114, a buffer 116 and a compressor/decompressor 118. The pre-  
processor 110 performs, for example, a correlated double  
20 sampling (CDS) for signal charge 10a supplied thereto to reduce  
noises, and performs a gamma correction for the signal 10a.  
The pre-processor 110 amplifies the signal 10a. Thus, the  
amplified signal 10a is output to the A/D converter 112.

25 The A/D converter 112 samples the analog signal 10b  
supplied from the image pickup device 104 through the pre-  
processor 110, in response to a clock signal 120b supplied  
from the signal generator 120, which generates also a timing  
signal 120a, and using the control signal 12b from the system  
30 control 12, and quantizes the analog signal 10b, thus converting  
the signal 10b to a digital signal 10c. The resultant digital  
signal 10c is supplied to the signal processor 114.

The signal processor 114 performs the automatic exposure



1 control, the white balance control (AWB: Automatic White  
Balance control) and the aperture correction for the signal  
10c supplied, and then performs a signal processing in  
5 accordance with the two modes. Specifically, these two modes  
are directed to the modes set by a shutter release button 128  
of a mode setting section 10E, described later, namely, a still  
picture shoot mode in which an obtained still image data is  
transferred to a storage 126 of a signal output system 10D,  
and simply a light control mode in the automatic focusing (AF)  
10 of the image pickup system 10A. A gamma correction may be  
performed in this stage or in a later stage.

15 In the digital still camera 10, which mode is to be  
selected is controlled by the control signal 12b from the system  
control 12. In the still picture shoot mode, under the control  
of the system control 12, the signal processor 114 performs  
a digital signal processing, such as the broadening of the  
band of the luminance signal on the signal which has been  
undergone the foregoing signal processing.

20 On the other hand, in the mode of controlling a light  
measurement, taking into account that the supplied signal 10c  
is digital, the system control 12 is adapted to perform a  
control such that the signal from the image pickup device 104  
25 is read out faster than the conventional reading-out rate,  
and process the signal read out. In addition, the vertical  
thinning down of the lines is performed so as to allow the  
display 124 of the signal output system 10D to display the  
image representative of the image signal. The signal processor  
30 114 performs a signal processing in the still picture shoot  
mode so as to convert the digital image signal 10c to a  
recordable video signal. Then, the signal processor 114 outputs  
to the buffer 116 the signal 10d in the mode in which a  
display/record is selected.

1           The buffer 116 has a function to amplify the video signal  
10d supplied from the aforementioned signal processor 114 with  
a predetermined gain as well as to perform a control on its  
time axis in recording. Under the control of a recording  
5       control (not shown) arranged in the system control 12, the  
buffer 116 outputs the picture signal 10e either to the signal  
output system 10D or to the compressor/decompressor 118 or  
both.

10           In recording the picture, the compressor/decompressor  
118 takes a picture signal 10e thereinto in response to the  
control signal 12b of the system control 12. The supplied  
picture signal 10e undergoes a compression based on, the Joint  
Photographic coding Experts Group (JPEG) standard, for example.  
15       When the signal 10f recorded is read out from the storage 126,  
the signal 10f is subjected to a signal processing such as  
a conversion reverse to the foregoing compression processing,  
whereby the original picture signal is reproduced. The restored  
picture signal (not shown) is supplied to the display 124 and  
20       displayed thereon.

          The drive signal generation section 10C includes the signal  
generator 120 and a driver 122. The signal generator 120  
generates synchronous signals 120b based on clock signals  
25       locally oscillated so as to drive the digital still camera  
10 in, for example, a present broadcast system (NTSC/PAL) and  
supplies the signal 120b to the signal processor 114. The  
signal generator 120 supplies the signal 120b as clock signals  
for use in generating a sampling signal and a read/write signal  
30       to the pre-processor 110, the A/D converter 112, the buffer  
116 and the compressor/decompressor 118.

          The signal generator 120 generates the synchronous signals  
from the locally oscillated clock signals, and, using these

1 signals, generates a variety of timing signals 120a. The  
generated timing signals 120a include timing signals used for  
reading out the signal charge excited in the image pickup device  
5 104, such as, vertical timing signals which define timings  
for driving the vertical transfer paths, horizontal timing  
signals which define timings for driving the horizontal transfer  
paths and timing signals which are used to perform field shift  
and line shift. Moreover, the signals from the signal generator  
120 are also used for controlling operations of the AF control  
10 106 and the AE control 108. The lines conveying those signals  
are not illustrated apparently.

Thus, the various kinds of signals are output to the  
foregoing circuit components, and the signal generator 120  
15 supplies the vertical timing signals and the horizontal timing  
signals to the driver 122. When the control signal 12b in  
the mode of controlling a light measurement (photometry mode)  
is supplied from the system control 12 to the signal generator  
120, the signal generator 120 supplies a signal for elevating  
20 the substrate voltage of the photosensitive cells, that is,  
an overflow drain voltage for the photosensitive cells of the  
colors R and B, according to demand, for example, in the mode  
of controlling a light measurement. The supply of this signal  
enables a signal reading out prohibited state to be set.

25  
For example, in the photosensitive cell of colors R and  
B, a state is set which is similar to one where no signal  
charges are generated at all. In the photometry mode, the  
signal generation section 120 generates a transfer gate signal  
30 to read out signal charges from a photosensitive cell that  
has received a signal reading out permission. When the  
photometry mode is selected, the signal generation section  
120 selectively switches the timing signals in response to  
the control signal 12b from the system control 12. The driver

1 122 generates a drive signal 122a at the supplied timings.  
Generally, to change a signal reading out speed, a vertical  
drive signal output from the driver 122 in a selected mode  
is supplied to the image pickup device 104, so that a drive  
5 for the entire photosensitive array, a drive for selected colors  
and a drive based on the thinning rate of pixels are performed.

The driver 122 outputs a corresponding drive signal 122a,  
especially when the mode is set to the photometry mode. To  
10 change a drive signal level appropriately for a mode, a level  
switch is provided to perform the switching. Generally, a  
voltage level is selected from 1V, 5V, 8V and 12V in the  
illustrative embodiment. The driver 122 generates a drive  
signal 122a timed with the timing signal 120a supplied from  
15 the signal generation section 120. The driver 122 generates  
a tri-state drive signal from the vertical timing signal and  
the transfer gate signal.

The signal output system 10D includes the display 124  
20 and the storage 126. In the display 124, a liquid crystal  
display monitor of the VGA (Video Graphics Array) standard  
supplied with inputs of digital RGB signals is provided. The  
storage 126 is adapted to store the video signal 10f supplied  
to a magnetic recording medium, a semiconductor memory used  
25 for a memory card, an optical recording medium or a magneto-  
optical recording medium. Moreover, the storage 126 is also  
capable of reading out the video signal 10f thus stored so  
to be displayed on the display 124. With the type of storage  
126 in which the recording medium is detachably mounted the  
30 recording medium may be detached so as to reproduce the video  
signal recorded on the recording medium by an external apparatus  
to display and/or print the picture.

The mode setting section 10E includes a release button

1 128 and key switches 130. In this embodiment, a two-stroke  
button mechanism is provided in the release button 128.  
Specifically, in the half-depressed state as the first stroke,  
the photometry mode is set to develop a signal representing  
5 the photometry mode set to the system control 12. In the fully-  
depressed state as the second stage, the signal defining the  
timing for taking the picture is supplied to the system control  
12 to notify the system control 12 of fact that the picture  
recording mode, or the still picture shoot mode, was selected.  
10 The settings of these modes are reported to the system control  
12 on a signal line 28. Furthermore, when the shutter release  
button 128 is in its state of powering the camera 10 on and  
a switch (not shown) of the image monitoring display is in  
its ON state, the system control 12 based on the signal supplied  
15 through the release button 128 controls the display 124 so  
as to display a moving picture in the moving picture mode.

The key switches 130 is a cross-shaped key, which selects  
items and picture images by moving a cursor in all directions  
20 (e.g. up-/down-ward/right-/left-ward), which is displayed on  
the screen of the display 124. The selected information is  
also sent to the system control 12 on a signal line 30.  
Especially, the key switch 130 selects a thinning rate of pixels  
set to  $1/2$ ,  $1/4$  or  $1/8$  in the photometry mode, and supplies  
25 the selected thinning rate to the system control 12. This  
setting prescribes for the way of reading out signal charges  
used for AE and AWB in the photometry mode.

The system control 12 is adapted for controlling the  
30 general operation of the camera. The system control 12 includes  
a central processing unit (CPU). The system control 12 decides,  
based upon the input signal 28 from the release button 128,  
which mode is selected. Furthermore, the system control 12  
controls the processing on the picture signal of the camera

1 by selection information 30 from the key switches 130 as  
described above. Based on the supplied information, the system  
control 12 controls the operation of the drive signal generation  
section 10C based on the supplied information. The system  
5 control 12 includes a recording control (not shown). The  
recording control controls operations of the storage 126 of  
the signal output system 10D and the buffer 116 in response  
to a timing control signal 12c from the system control 12.

10 Now, the operation of the digital still camera 10  
constructed as discussed above will be described. First,  
description will be made on the whole-pixel reading out usually  
carried-out. The digital still camera 10 is normally provided  
with the image pickup device 104 capable of performing whole-  
15 pixel reading out. Thus, if an indication of the still picture  
shoot mode is produced by the release button 128, a light  
incident through the color separation filter CF of the honeycomb  
type stripe pattern is received by the entire photosensitive  
array. Each photosensitive cell 104a performs photoelectric  
20 conversion upon having received the light, and then accumulates  
signal charges.

To read out the accumulated signal charges from the  
photosensitive cells 104a, as shown in FIG. 5, the signal  
25 generation section 120 generates a vertical synchronous signal  
VD. Also, the signal generation section 120 generates vertical  
timing signals  $V_1$  to  $V_8$  to be supplied to the transfer devices  
 $V_1$  to  $V_4$  and  $V_5$  to  $V_8$  of the vertical transfer path 104c and  
transfer gate signals  $TG_1$ ,  $TG_3$ ,  $TG_5$  and  $TG_7$  to be supplied to  
30 the signal reading out gate 104b in synchronization with the  
vertical synchronous signal VD. FIG. 5 schematically shows  
that in each vertical synchronization period of time, the  
vertical timing signals  $V_1$ ,  $V_4$ ,  $V_5$  and  $V_8$  are negative signals,  
and the vertical timing signals  $V_2$ ,  $V_3$ ,  $V_6$  and  $V_7$  are positive

1 signals. It can be understood that the transfer gate signals  
TG<sub>1</sub>, TG<sub>3</sub>, TG<sub>5</sub> and TG<sub>7</sub> are generated to read out signal charges  
in synchronization after the inputs of the vertical synchronous  
5 signal VD from each photosensitive cell. The timing  
relationship can be understood from FIG. 6, which is enlarged  
in time axis.

More specifically, in this stage, signal charges are read  
out only from the photosensitive cell in a position associated  
10 with the vertical timing signals V<sub>1</sub> and V<sub>5</sub> when the transfer  
gate is switched ON, and no field shift is carried out until  
a next vertical synchronous signal is supplied (also see FIG.  
5). Then, after field shift, the vertical timing signals are  
supplied in sequence in synchronization with a horizontal  
15 synchronous signal HD. The supply of these signals causes  
the signal charges shifted to the vertical transfer path 104c  
to be transferred toward the horizontal transfer path 104d.

FIG. 7 shows in an enlarged scale the timings of the  
vertical timing signals and the transfer gate signals after  
20 the vertical synchronous signal VD has been changed to its  
level "H" and the horizontal synchronous signal HD has risen  
in the timing relations of FIG. 6. Especially, after the  
vertical timing signals V<sub>1</sub> and V<sub>5</sub> and the transfer gate signals  
TG<sub>1</sub> and TG<sub>5</sub> have been supplied to the driver section 122,  
25 vertical drive signals  $\phi V_1$  and  $\phi V_5$  are output to the image pickup  
device 104. Subsequently, potentials shown in FIG. 7 are formed  
in the vertical transfer devices V1 and V5. Since the transfer  
gate signals TG<sub>3</sub> and TG<sub>7</sub> are also switched ON, vertical drive  
signals  $\phi V_3$  and  $\phi V_7$  are generated. Accordingly, the potentials  
30 are formed as shown in FIG. 7.

FIG. 8 is a timing chart showing how the signal charges

002210-347250

1 shifted to the vertical transfer path 104c are transferred  
toward the horizontal transfer path 104d. The vertical transfer  
path 104c is indicated in the form of vertical transfer devices  
V1 to V8. It can understood that two identical vertical drive  
5 signals are supplied respectively to the vertical transfer  
devices V1 to V4 and the vertical transfer devices V5 to V8.  
In other words, driving is performed by four signals having  
different phases. After the line shift has been performed  
for the vertically transferred signal charges, signal charges  
10 of all the pixels are read out from the image pickup device  
104 at once within a specified period of time by transferring  
the horizontal transfer paths 104d in sequence.

15 Consideration is now given to typical image pickup  
operations procedures of the digital still camera 10. First,  
in the digital still camera 10, a photometry or light  
measurement is performed for an object field before an image  
pickup. To pick up an image of the object field, the release  
button 128 is depressed to its half stroke, thus setting the  
20 photometry mode. In this case, to perform AF adjustment  
control, only color G from signals obtained by the photoelectric  
conversion in the image pickup device 104 of the image pickup  
system 10A is extracted. This is because the information of  
color G, occupying about 70% of the luminance information,  
25 is only necessary for performing the AF adjustment control.  
In the light measurement in the auto focusing AF, pixel  
information must be repeatedly read out until an appropriate  
value is detected. Thus, there is a request for reading out  
signal charges at a speed as high as possible.

30 On the other hand, to perform AE and AWB adjustment  
control, as information about all colors is necessary, such  
single color reading out is not sufficient, but rather all  
color components of the color separation are used. More



1 detailed description will be made later of the ways of  
generating and supplying the drive signal 122a and performing  
high-speed signal reading out in connection with driving of  
the image pickup device 104 when the AE and AWB adjustment  
5 control is performed according to the embodiment. As described  
above, in the photometry mode, reading out of single color  
G and thinning and reading out of all the colors are carried  
out.

10 The picture signal 10a obtained by the image pickup system  
10A following the light measurement is then supplied to the  
signal processing system 10B under the control of the system  
control 12. In the signal processing system 10B, the supplied  
picture signal 10a is converted into a digital signal 10c by  
15 the A/D converter 112 through the pre-processor 110. The image  
data 10c obtained by the conversion is then supplied to the  
system control 12 in the form of light measurement information,  
although not shown. The system control 12 uses this light  
measurement information for further processing. In the  
20 processing, the system control 12 generates control signals  
12a for AE control and also for AF control, and outputs these  
control signals respectively to the AF and AE control 106 and  
108. The AF and AE control 106 and 108 perform the AF and  
AE controls in response to the control signals 12a supplied  
25 through the respective mechanisms incorporated therein. These  
adjustments are carried out repeatedly in the above mode.

Then, the user further depresses the release button 128  
to its full stroke at a desired image shooting timing. At  
30 this time, a signal recording for an image of the object field  
is supplied to the system control 12. As in the case of the  
previous mode, the image pickup system 10A performs image pickup  
for a light incident from the object field. In this still  
picture shoot mode (the whole-pixel reading out), however,

1 processing for taking out all the colors is carried out in  
the image pickup device 104 without any pixel thinning. Before  
the image pickup, needless to say, a drive signal to be supplied  
is different from that in the previous signal reading out.

5

The picture signal 10a produced is converted into a digital  
signal 10c by the A/D converter 112 of the signal processing  
system 10B, and then supplied to the signal processor 114.  
The signal processor 114 performs a signal processing on the  
10 image data corresponding to a luminance signal and a color  
difference signal so as to be extended to a higher frequency  
band. Then, obtained image data 10d is supplied through the  
buffer 116 to the compressor/decompressor 118. The  
compressor/decompressor 118 performs a compression on a signal  
15 10f, and outputs the compressed signal to the signal output  
system 10D. In the still picture shoot mode, the image data  
10f of all the pixels supplied under the control of the  
recording control section in the system control 12 is recorded  
in the storage 126. The storage 126 will develop the recorded  
20 image data under the control of the recording control section.

Thus, the digital still camera 10 can be used for both  
of the photometry mode and the still picture shoot mode by  
manipulating release button 128. In the digital still camera  
25 10, including an image pickup device having a large number  
of pixels exceeding one million, in the still picture shoot  
mode, time necessary for reading out the all pixels of an image  
signal is not such a big problem except when continuous shooting  
is carried out. But in the photometry mode, as described above,  
30 reading out time needs to be shortened when AE or AF control  
is performed. Next, description will be made of operations  
of the image pickup device 104 and the drive signal generation  
section 10C in the photometry mode for performing AE control  
in the digital still camera 10 by using the image pickup system

1 10A having the above-described specifications.

As the honeycomb type stripe pattern is employed for the color separation filters CF, it can be understood from FIG. 4 that the photosensitive cells 104a of color R are adjacent to the vertical transfer devices V1 and V5, and the photosensitive cells 104a of color G are adjacent to the vertical transfer devices V3 and V7. In this case, the transfer gate signals TG<sub>3</sub> and TG<sub>7</sub> are supplied to make the signal reading out gates 104b adjacent to the vertical transfer devices V1 and V5 is switched to the OFF state thereof, and the signal reading out gates 104b adjacent to the vertical transfer devices V3 and V7 is switched to the ON state thereof. These timing relations are shown in FIG. 9. The other transfer gate signals TG<sub>1</sub> and TG<sub>5</sub> are at "H" levels. Accordingly, the signal reading out gates 104b adjacent to the vertical transfer devices V1 and V5 are in the OFF states thereof, so that signal charges of colors R, G and B cannot be read out. These relations are indicated by the hatched pixels of reading out prohibited lines of signal charges and reading out permitted lines of signal charges shown in FIG. 10.

Because of the above relations, as shown in FIG. 11A, signal charges are read out from the photosensitive cells R1, G1, B1, R2, G2, B2, and so on, to the vertical transfer paths 104c. The signal charges read out to the vertical transfer paths 104c are then transferred in sequence toward the horizontal transfer path 104d as described above. At this time, all the signal charges in the vertical transfer paths 104c are moved in the lower direction by transfer distances corresponding to two lines. As a result, the signal charges of the photosensitive cells R1, G1 and B1 closest to the horizontal transfer path 104d are supplied to the horizontal transfer path 104d.

1 Accordingly, the signal charges of the photosensitive  
cells R1, G1 and B1 are moved by two lines, but the movements  
thereof in the second lines are line-shifted. Since no signal  
charges are read out from the photosensitive cells indicated  
5 by hatched lines, a transfer device in the horizontal transfer  
path 104d which the signal charges should have entered is  
indicated by symbol E (emptiness or lack of signal charge),  
see FIG. 11B. Then, the signal charges E, R1, E, G1, E, B1,  
and so on, that have reached the horizontal transfer path 104d  
10 are transferred in sequence to the amplifier 104e arranged  
on the output side (not shown in FIG. 11), and output from  
the latter. Subsequently, all the signal charges remaining  
in the vertical transfer paths 104c are moved in the lower  
direction again by two lines (see FIG. 12A). Then, the signal  
15 charges E, R2, E, G2, E, B2, and so on, that have reached the  
horizontal transfer path 104d, are transferred in sequence  
toward the amplifier 104e arranged in the output side, and  
output from the latter (see FIG. 12B).

20 By the above-mentioned transfer of the signal charges,  
the signal charges only from the photosensitive cells indicated  
by the hatched lines in FIG. 10 are read out. In the  
arrangement of FIG. 10, the 1/2 thinning is carried out both  
in the horizontal and vertical directions. However, this  
25 arrangement employs the honeycomb-like structure as described  
above, where the pitches of pixel shifting are offset by 1/2  
in the vertical and horizontal directions. Thus, the number  
of actually read out pixels is not equal to the number of pixels  
of the 1/4 thinning of all the pixels, even when the 1/2  
30 thinning is performed both in the vertical and horizontal  
directions. Reading-out of the signal charges to the vertical  
transfer device is not carried out, so that by dealing with  
that element of the device as "E" in this transfer device, the  
signal charges can be processed exactly like actual signal

1 charges.

5 In other words, in the vertical transfer, these signal charges "E" can be ignored, whereas in the transfer of a horizontal direction, transfer is carried as if the signals "E" had signal charges "E" occupying the positions of one transfer device. Accordingly, the number of the transfer stages through which the horizontal transfer is made is the same as that of the transfer stages encountered when no thinning is carried out (see FIGS. 11C and 12B).

15 Thus, the inventor studied the way of reading out signal charges to perform the 1/2 thinning also in the number of transfer stages in the horizontal direction. The procedures are as follows. As shown in FIG. 11A, signal charges are read out. Then, in the vertical transfer also, all the signal charges read out on a two-line (two-stage) basis are transferred in the same manner as in the case shown in FIG. 11B. Thus far, the procedures are the same as those in the previous procedures.

20 Then, in the horizontal transfer, the signal charges are moved by two stages on the transfer path 104d in the horizontal direction. For this reason, the horizontal transfer path 104d has a structure capable of holding at least extra transfer devices equivalent to two stages to hold the signal charges. In this case, as a line of signals not to be read out is provided, a transfer device equivalent to one stage only needs to be added. As a result, the signal charges of colors R, G and B are sent directly below the vertical transfer paths for transferring "E" (see FIG. 13A). Then, the same vertical transfer as that described above is carried out by two lines. In this way, the remaining signal charges are transferred in the lower direction by two stages. Areas "E" exist in positions

1 where the colors R1, G1 and B1 were located before the transfer,  
i.e., directly below the vertical transfer paths. Signal  
charges R2, G2 and B2 are vertically transferred to the  
positions of "E" by two lines (see FIG. 13B). In both FIGS.  
5 13A and 13B, even if the signal charges are transferred to  
the positions indicated by signal charges "E" no mixing occurs  
between "E" and any one of transferred colors R, G and B.  
Accordingly, the signal charges of colors R1, R2, G1, G2,  
B1 and B2 are held without being mixed.

10

As a result, the signal charges of colors R, G and B  
equivalent to two lines are housed in the horizontal transfer  
path 104d of FIG. 13B. In the horizontal transfer after the  
second vertical transfer, all the signal charges R1, R2, G1,  
15 G2, B1, B2, and so on, of two lines of the color are read out  
at once from the horizontal transfer path 104d. This transfer  
processing enables the signal charges equivalent to two lines  
to be read out within the time period of usual one-line reading  
out (see FIG. 14). In other words, the 1/2 thinning is carried  
20 out in the horizontal direction.

20

By the foregoing procedures, the 1/2 thinning is performed  
both in the horizontal and vertical directions. Accordingly,  
compared with the time for the whole-pixel reading out, required  
25 time can easily be shortened by 1/4. It may be advisable to  
prevent any signal charges from remaining in the transfer paths  
by performing high-speed transfer before reading out.

25

To perform the 1/4 thinning for reading out of all the  
30 pixels, for example, as shown in FIG. 15, a pulse is applied  
to the transfer gate signal TG<sub>7</sub>. In response to this pulse,  
the signal reading out gate is switched ON for one line. This  
situation of FIG. 15 is shown more specifically in FIGS. 16  
and 17, which are timing charts showing a horizontal synchronous

30

1 signal HD in an enlarged scale.

5 A drive signal thus obtained from the transfer gate signal TG<sub>7</sub> is supplied to the image pickup device 104. Upon having received the drive signal, first, as shown in FIG. 18A, paying attention to the photosensitive cells adjacent to each other in two lines, for example, transfer gate signals TG<sub>1</sub> and TG<sub>3</sub> are supplied to the line of color G of the left end adjacent to color R, and transfer gate signals TG<sub>5</sub> and TG<sub>7</sub> are supplied to the line of color R held between colors G and B. In this relation, if the transfer gate signal TG<sub>7</sub> is supplied, to drive each four photosensitive cells arranged in two lines, signal charges accumulated by light receiving are read out only from one photosensitive cell. At this stage, the signal reading out has been done to a quarter of the entire pixels. The further transfer in the vertical (column) direction is carried out in the lower direction on a two-stage basis in the vertical transfer paths 104c (see FIG. 18B).

20 The signal charges supplied to the horizontal transfer path 104d are transferred toward the output side on a two-stage basis (see FIG. 18C). After this transfer, vertical transfer is carried out by two stages (see FIG. 19A). In this way, the signal charges equivalent to four lines in amount are stored altogether in the horizontal transfer path 104d. The stored signal charges are then read out to a next horizontal transfer path (see FIG. 19B). By such horizontal transfer, the 1/2 thinning is performed by reading out from two lines at once. For this signal reading-out, the thinning results in  $1/4 \times 1/2 = 1/8$  considering the overall transfer in the horizontal and vertical directions. From the four transfer gate signals, one may be selected.

1 In the foregoing example, the rate of thinning in the  
horizontal direction was  $1/2$ . Next, description will be made  
of a process of transfer where thinning in the horizontal  
5 direction is set to  $1/4$  which is the same as in the case of  
the rate of thinning in the vertical direction. As shown in  
FIG. 20A, by supplying a pulse of the transfer gate signal  
TG<sub>7</sub>, signal charges of colors R<sub>1</sub>, G<sub>1</sub>, B<sub>1</sub>, and so on, and colors  
of R<sub>3</sub>, G<sub>3</sub>, B<sub>3</sub>, and so on, are read out to the respective  
10 vertical transfer paths 104c. It may be advisable to completely  
prevent any charges from remaining in the transfer paths by  
performing high-speed transfer before reading out of these  
signal charges.

15 In the initial vertical transfer, the signal charges in  
the vertical transfer paths 104c are transferred by two stages.  
As a result, colors R<sub>1</sub>, G<sub>1</sub>, B<sub>1</sub>, and so on, are supplied to  
the horizontal transfer path 104d (see FIG. 20B). Subsequently,  
the vertical transfer based on a process different from the  
conventional process is carried out. In other words, all the  
20 signal charges remaining in the vertical transfer paths 104c  
are transferred by four stages. By this transfer, the signal  
charges of colors R<sub>3</sub>, G<sub>3</sub>, B<sub>3</sub>, and so on, are supplied to the  
horizontal transfer path 104d. In the transfer devices of  
the horizontal transfer path 104d directly below the vertical  
25 transfer paths 104c from which the signals have been read out,  
the signals of identical colors, i.e., colors (R<sub>1</sub>+R<sub>3</sub>), (G<sub>1</sub>+G<sub>3</sub>)  
and (B<sub>1</sub>+B<sub>3</sub>), are combined (see FIG. 20C). At this time, in  
the transfer devices of the horizontal transfer path 104d  
directly below the vertical transfer paths 104c from which  
30 no signal charge reading-out has been carried out, no changes  
occur with "E" added. From the horizontal transfer path 104d,  
the stored signal charges are transferred toward the output  
side by two stages (see FIG. 20D).



1           For vertical transfer thereafter, transfer of four stages  
is repeated by twice. In the first transfer, as shown in FIG.  
21A, the signals of colors R5, G5 and B5 are supplied to the  
horizontal transfer path 104d. In the next second transfer,  
5       the signals of colors R7, G7 and B7 are supplied to the  
horizontal transfer path 104d. In this way, in the transfer  
devices which have received the signal charges by the first  
transfer, the signals of identical colors, i.e., colors (R5+R7),  
(G5+G7) and (B5+B7), are synthesized (see FIG. 21B). By such  
10       signal synthesizing of the identical colors, the thinning in  
the transfer of the horizontal direction will result in  $1/4$   
in total by further thinning the signal charges by  $1/2$  in the  
horizontal direction. After the signal synthesizing, all the  
signals stored in the horizontal transfer path 104d are output.  
15       For this signal reading out, the thinning results in  $1/4 \times$   
 $1/4 = 1/16$  for all the pixels.

20           With the above-described constitution, the present  
situation in which the trial to meet the demand for a high  
integration of the photosensitive array obstructs antinomically  
the high-speed reading out of the signal charge can be  
comparatively easily solved by accurately reading out all the  
colors to be used. Thus, the present invention can be used  
for the AE and AWB control which requires the fast reading  
25       out of the signal charge from the image pickup device. Since  
the image pickup section serves as a light measurement sensor,  
a dedicated light measurement sensor can be omitted.

30           The entire disclosure of Japanese patent application No.  
20068/1999 filed January 28, 1999 including the specification,  
claims, accompanying drawings and abstract of the disclosure  
is incorporated herein by reference in its entirety.

1           While the present invention has been described with  
reference to the particular illustrative embodiments, it is  
not to be restricted by those embodiments but only by the  
appended claims. It is to be appreciated that those skilled  
5       in the art can change or modify the embodiments without  
departing from the scope and spirit of the present invention.

[illegible]

**WHAT IS CLAIMED IS:**

1           1. A solid-state image pickup apparatus including a  
plurality of photosensitive cells for performing a photoelectric  
conversion for incident light arranged two-dimensionally in  
a photosensitive array for receiving the incident light, the  
5       photosensitive cells being arranged obliquely adjacent to each  
other at positions shifted from each other by a length in row  
and column which is substantially equal to the half of a pitch  
at which the photosensitive cells are disposed in the row and  
column direction, wherein an image signal output from an image  
10       pickup section for transferring signal charge obtained by the  
photoelectric conversion by each of the photosensitive cells  
in response to a drive signal at a predetermined timing is  
converted to a digital signal, and a picture signal is generated  
by performing a signal processing on the digital signal,

15               said image pickup section comprising:

              a color separator having color filters for separating  
the incident light into at least three separated colors,  
arranged in the column direction; and

              a signal reading out section for transferring the signal  
20       charge only to transfer devices each arranged in the column  
direction associated with one of said photosensitive cells,

              said apparatus comprising:

              a mode setting section for setting, among modes of reading  
out the signal charges from the image pickup section, either  
25       one of a whole-pixel reading out mode of reading out the signal  
charges from all of the plurality of photosensitive cells and  
a thinning reading out mode of reading out signal charges after  
thinning colors of the separated colors at a specified interval;

              a drive signal generation section for generating a drive  
30       signal according to instruction from the mode setting section,  
selecting a destination to which the drive signal generated  
according to the selected mode is supplied and then supplying  
the drive signal to the destination; and

35 a control section for controlling generation of a drive signal appropriately for the mode selected in the drive signal generation section upon receiving the instruction from the mode setting section, and signal processing executed for the image signal.

1 2. An apparatus in accordance with claim 1, wherein the separated colors are either one of a set of primary colors, red R, green G and blue B, a set of complementary colors, green G, yellow Ye and cyan Cy, and a set of complementary colors, gray Gray or white W, yellow Ye and cyan Cy.

1 3. An apparatus in accordance with claim 2, wherein in said color separator, the color filters are arranged in a column direction in a stripe shape, and a pattern having all colors set in one group is repeated in a row direction.

1 4. An apparatus in accordance with claim 2, wherein in the thinning reading out mode, said drive signal generation section supplies the drive signal to selectively drive the signal reading out section adjacent to each of the photosensitive cells by every other line.

1 5. An apparatus in accordance with claim 2, wherein in said image pickup section, a plurality of transfer devices are arranged in a column direction with eight as one unit, the drive signal is supplied through an electrode provided in the signal reading out section and corresponding to each transfer device, independently different from that in the whole-pixel reading out mode.

1 6. An apparatus in accordance with claim 4, wherein in the thinning reading out mode, said drive signal generation section supplies the drive signal only to one signal reading

out section while a plurality of transfer devices are set as  
one unit.

7. An apparatus in accordance with claim 4, wherein said  
drive signal generation section generates:

a first vertical drive signal for transferring the signal  
charges by two lines in a column direction after the signal  
reading-out section is driven;

a second vertical drive signal for transferring the signal  
charges by four lines in the column direction after the first  
vertical drive signal is supplied; and

a first horizontal drive signal for setting a transfer  
distance for transferring the transferred signal charges in  
a row direction to two columns.

8. An apparatus in accordance with claim 3, wherein in  
the thinning reading out mode, said drive signal generation  
section supplies the drive signal to selectively drive the  
signal reading out section adjacent to each of the  
photosensitive cells by every other line.

9. An apparatus in accordance with claim 8, wherein in  
said image pickup section, a plurality of transfer devices  
are arranged in a column direction with eight as one unit,  
the drive signal is supplied through an electrode provided  
in the signal reading out section and corresponding to each  
transfer device, independently different from that in the whole-  
pixel reading out mode.

10. An apparatus in accordance with claim 9, wherein in  
the thinning reading out mode, said drive signal generation  
section supplies the drive signal only to one signal reading  
out section while a plurality of transfer devices are set as  
one unit.

1 11. An apparatus in accordance with claim 10, wherein  
said drive signal generation section generates:

5 a first vertical drive signal for transferring the signal  
charges by two lines in a column direction after the signal  
reading-out section is driven;

a second vertical drive signal for transferring the signal  
charges by four lines in the column direction after the first  
vertical drive signal is supplied; and

10 a first horizontal drive signal for setting a transfer  
distance for transferring the transferred signal charges in  
a row direction to two columns.

1 12. A method of reading out an image signal from a  
plurality of photosensitive cells for performing a photoelectric  
conversion for incident light arranged two-dimensionally in  
a photosensitive array for receiving the incident light, the  
5 photosensitive cells being arranged obliquely adjacent to each  
other at positions shifted from each other by a length in row  
and column directions which is substantially equal to the half  
of a pitch at which the photosensitive cells are disposed  
in the row and column directions, wherein an image signal output  
10 from an image pickup section for transferring signal charge  
obtained by the photoelectric conversion by each of the  
photosensitive cells in response to a drive signal at a  
predetermined timing is converted to a digital signal, and  
a picture signal is generated by performing a signal processing  
15 on the digital signal,

said method comprising the steps of:

20 setting, among modes of reading out the signal charges,  
a whole-pixel reading out mode of reading out the signal charges  
from all of the plurality of photosensitive cells and a thinning  
reading out mode of reading out the signal charges by thinning  
colors of at least three separated colors at a specified

interval;

supplying the drive signal according to selected mode  
by the mode setting step, selecting a destination to which  
25 the drive signal is supplied and then supplying the drive signal  
to the destination;

separating each of the incident lights into the separated  
colors;

receiving the incident light color-separated by the color  
30 separation step by each of the plurality of photosensitive  
cells;

reading out all the signal charges obtained by the  
plurality of photosensitive cells in the whole-pixel reading  
out mode in response to the supplied drive signal after the  
35 light receiving step, and performing a field shift for only  
the signal charges read out from selected one of the plurality  
of photosensitive cells in response to the supplied drive signal  
in the thinning reading out mode;

transferring the signal charges transferred in the shift  
40 step in a column direction in response to the supplied drive  
signal; and

transferring the signal charges after transferred in the  
column direction transfer step and shifted by line in a  
horizontal direction in response to the supplied drive signal.

1 13. A method in accordance with claim 12, wherein the  
separated colors are either one of a set of primary colors,  
red R, green G and blue B, a set of complementary colors, green  
G, yellow Ye and cyan Cy, and a set of complementary colors,  
5 gray Gray or white W, yellow Ye and cyan Cy.

1 14. A method in accordance with claim 13, wherein said  
drive signal supply step includes the substeps of:

generating a field shift signal for reading out the signal

charges from each of the photosensitive cells corresponding  
5 to a line for reading in the thinning reading out mode, and  
supplying the field shift signal;

generating a column transfer timing signal for setting  
a transfer distance to two lines for transferring the signal  
charges in a column direction after the field shift signal  
10 is supplied, and then supplying the timing signal; and

generating a row transfer timing signal for transferring  
and outputting the transferred signal charges in a row direction  
after the transfer in the column direction and the line shift  
are performed, and repeating the supply of the row transfer  
15 timing signal to read out the signal charges of one of the  
separated colors.

1 15. A method in accordance with claim 14, wherein in said  
substep of generating the row transfer timing signal, a row  
transfer timing signal for setting a transfer distance to two  
columns is generated when the transferred signal charges are  
5 transferred in a row direction, and

in second one of said repeated substeps of the row transfer  
timing signal, all the line-shifted signal charges are read  
out.

1 16. A method in accordance with claim 14, wherein said  
substep of generating the column transfer timing signal  
includes:

a first column signal supply substep of first generating  
5 a column transfer timing signal for setting a transfer distance  
to two and four lines, totally six lines, when the signal  
charges are transferred in the column direction after the field-  
shifted signals are supplied, and then supplying the timing  
signal;

10 a first row signal supply substep of generating a row  
transfer timing signal for setting a transfer distance to two



columns when the transferred signal charges are transferred in the row direction after the first column signal supply substep, and supplying the timing signal;

15       a second column signal supply substep of generating a column transfer timing signal for setting a transfer distance to totally eight lines, comprising a couple of four lines, when the column signal supply substep is carried out again, and supplying the timing signal; and

20       reading out all the line-shifted signal charges after the second column signal supply substep.

1       17. A method in accordance with claim 14, wherein said substep of generating the column transfer timing signal includes:

5       a first column signal supply substep of first generating a column transfer timing signal for setting a transfer distance to two and four lines, totally six lines, when the signal charges are transferred in the column direction after the field-shifted signals are supplied, and then supplying the timing signal;

10       a first row signal supply substep of generating a row transfer timing signal for setting a transfer distance to two columns when the transferred signal charges are transferred in the row direction after the first column signal supply substep, and supplying the timing signal;

15       a second column signal supply substep of generating a column transfer timing signal for setting a transfer distance to totally eight lines, comprising a couple of four lines, when the column signal supply substep is carried out again, and supplying the timing signal; and

20       reading out all the line-shifted signal charges after the second column signal supply substep,

      said substep of generating the row transfer timing signal including the substeps of:

25 generating a row transfer timing signal for setting a  
transfer distance to two columns when the transferred signal  
charges are transferred in a row direction and supplies the  
timing signal, and

30 in second one of said repeated substeps of the row transfer  
timing signal, all the line-shifted signal charges are read  
out.

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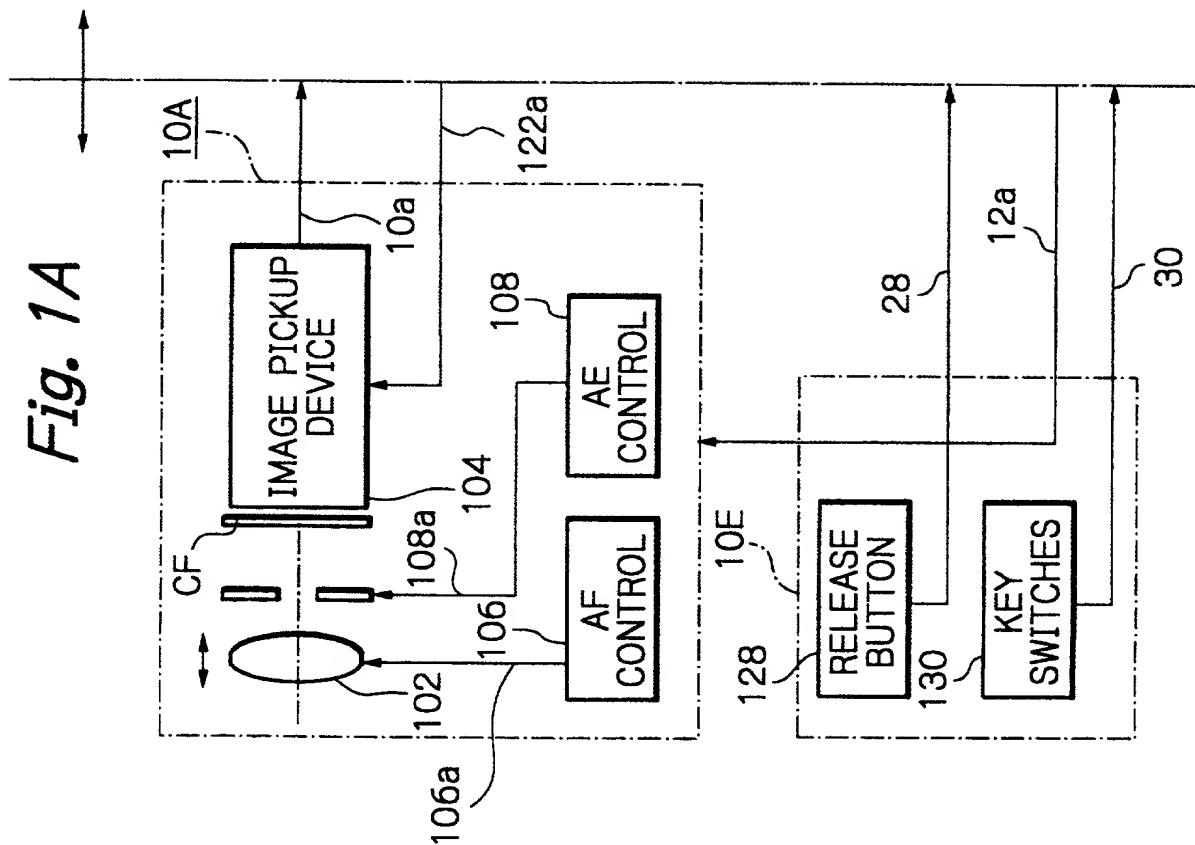
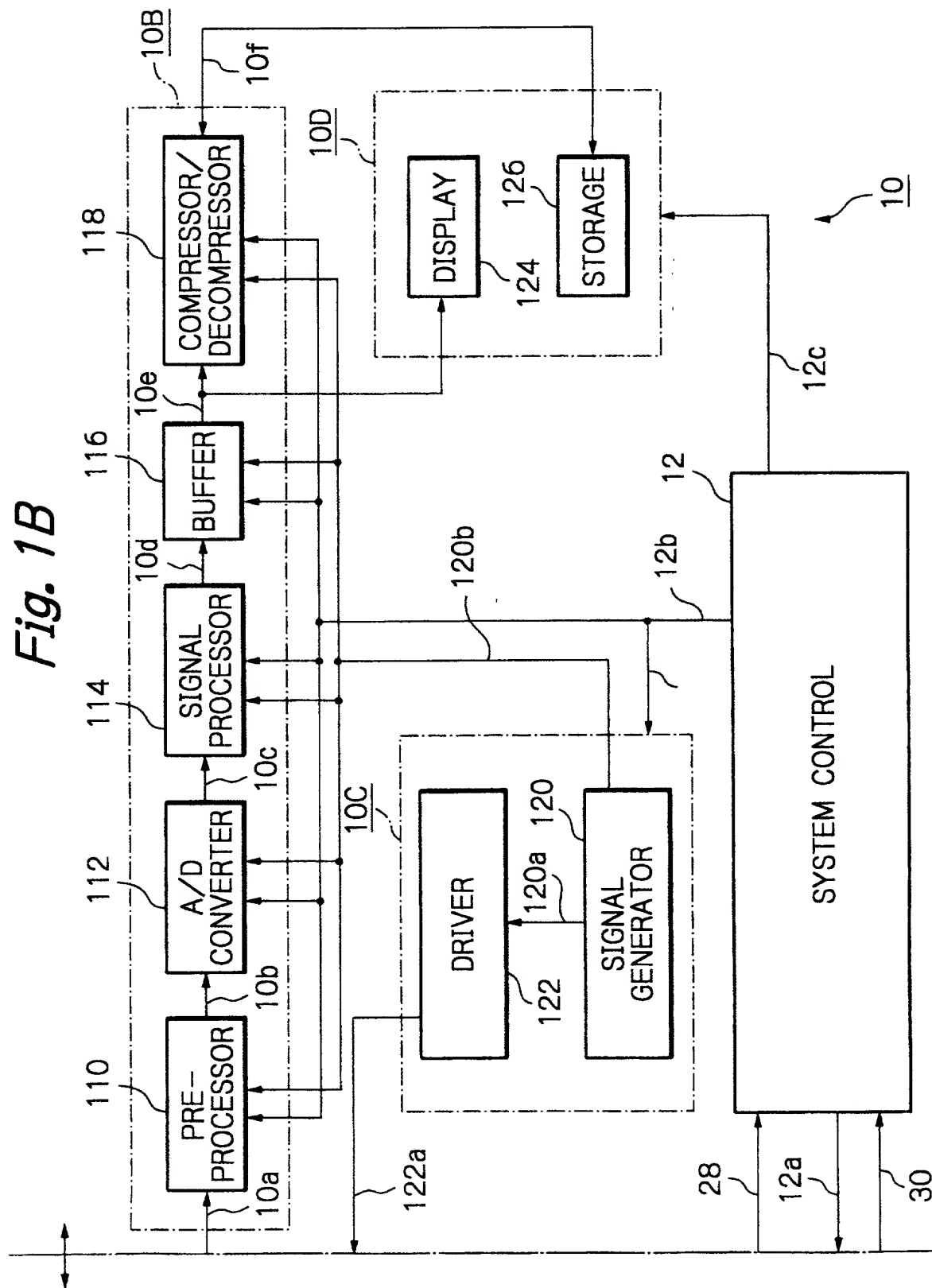


Fig. 1A

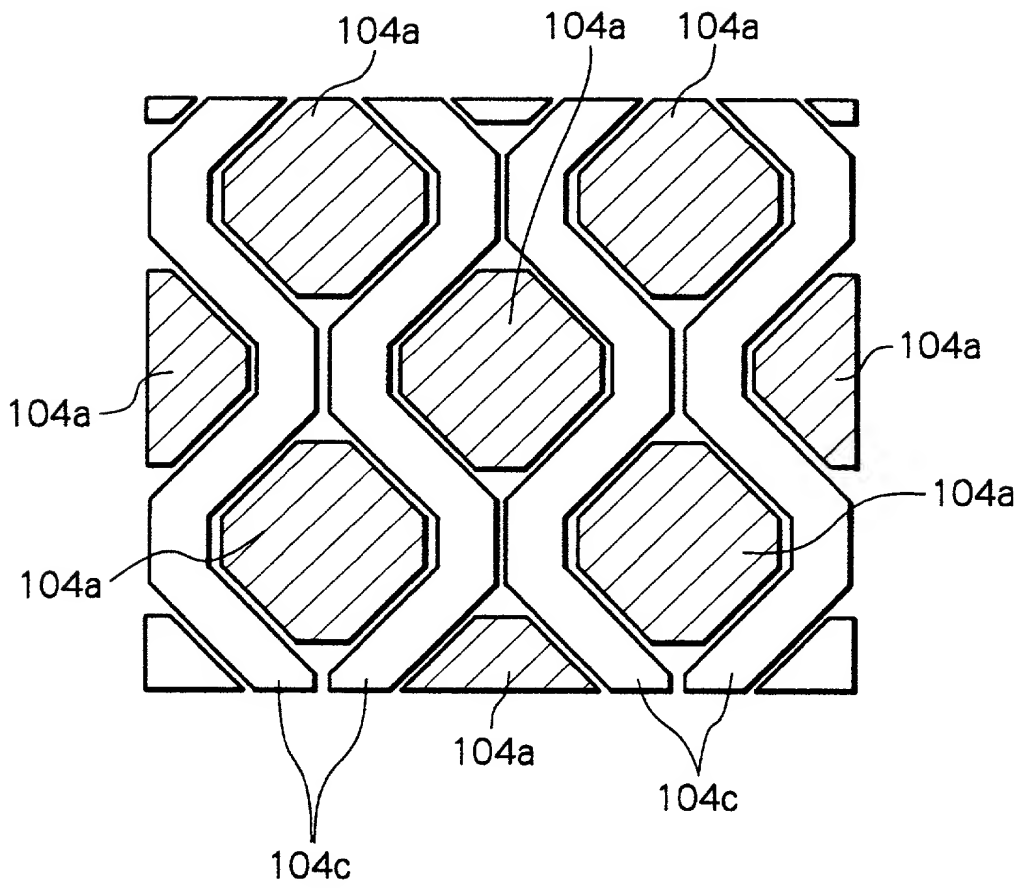
Fig. 1

Fig. 1A Fig. 1B

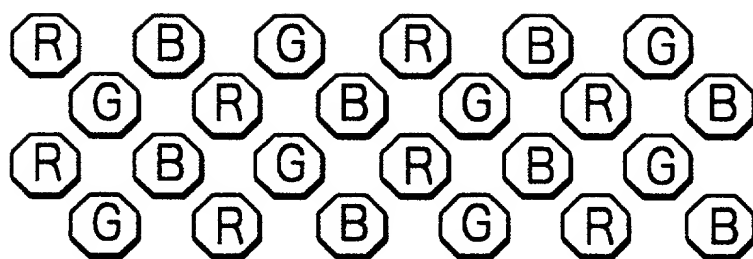
Fig. 1B



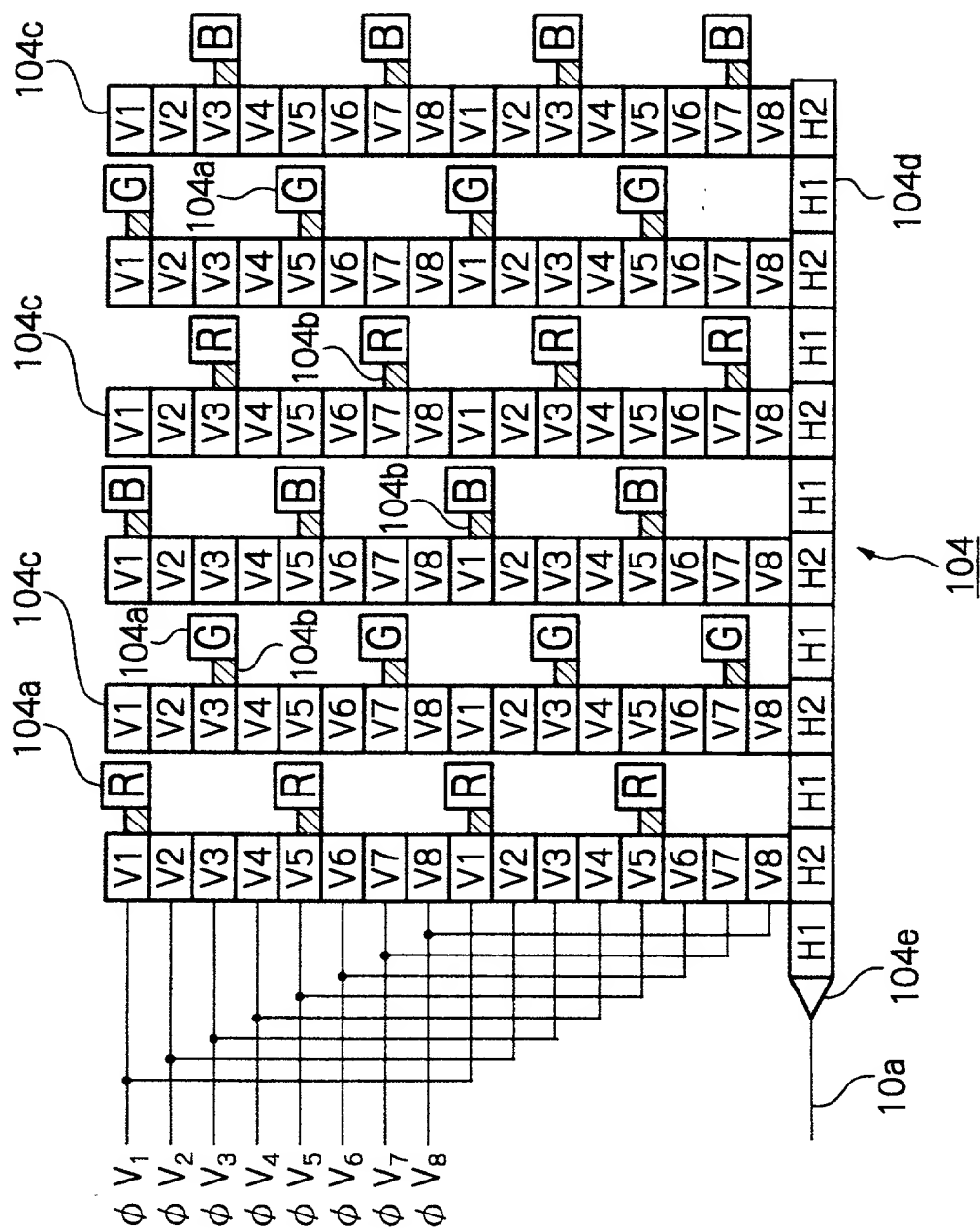
*Fig. 2*



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**Fig. 4**





*Fig. 5*

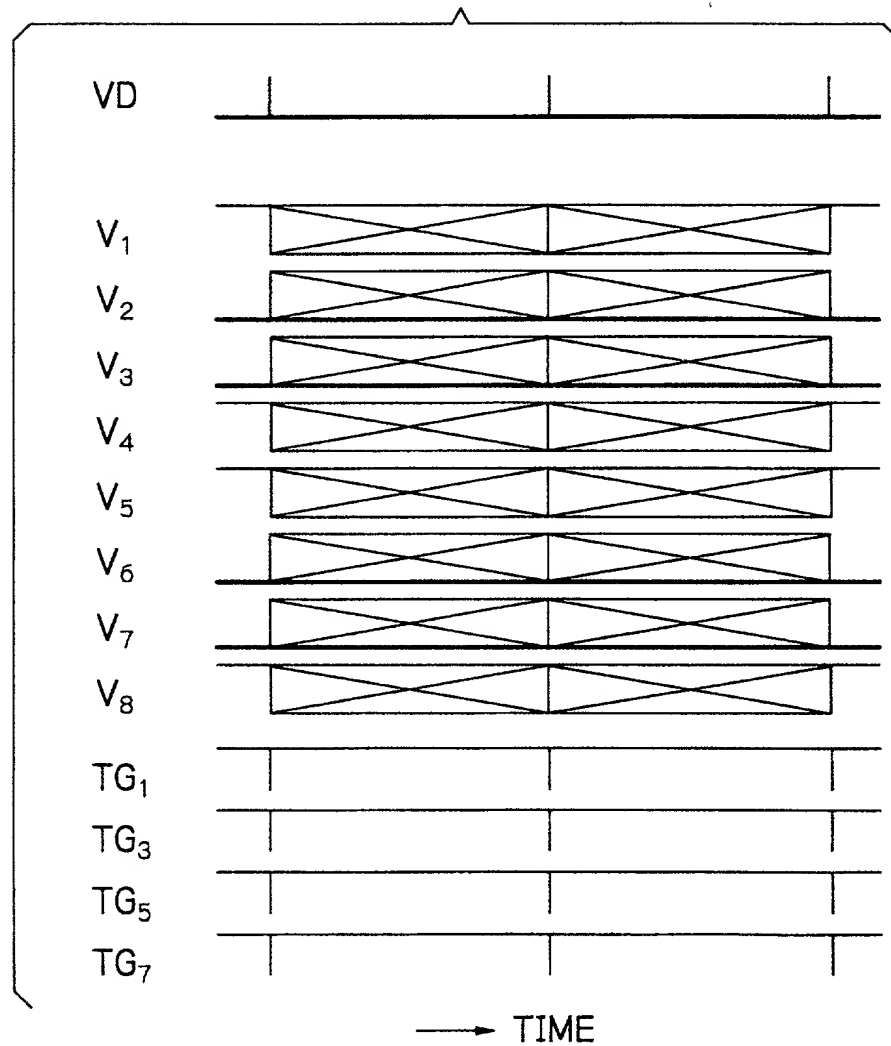


Fig. 6

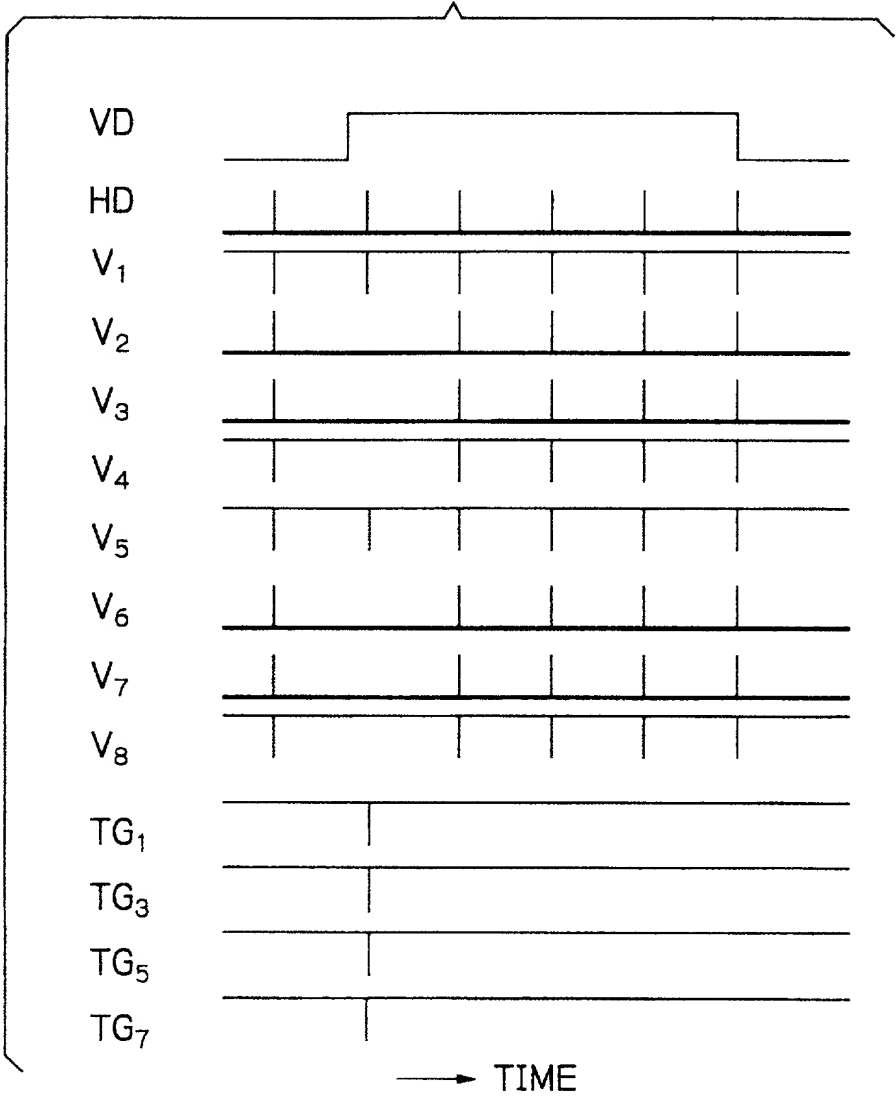
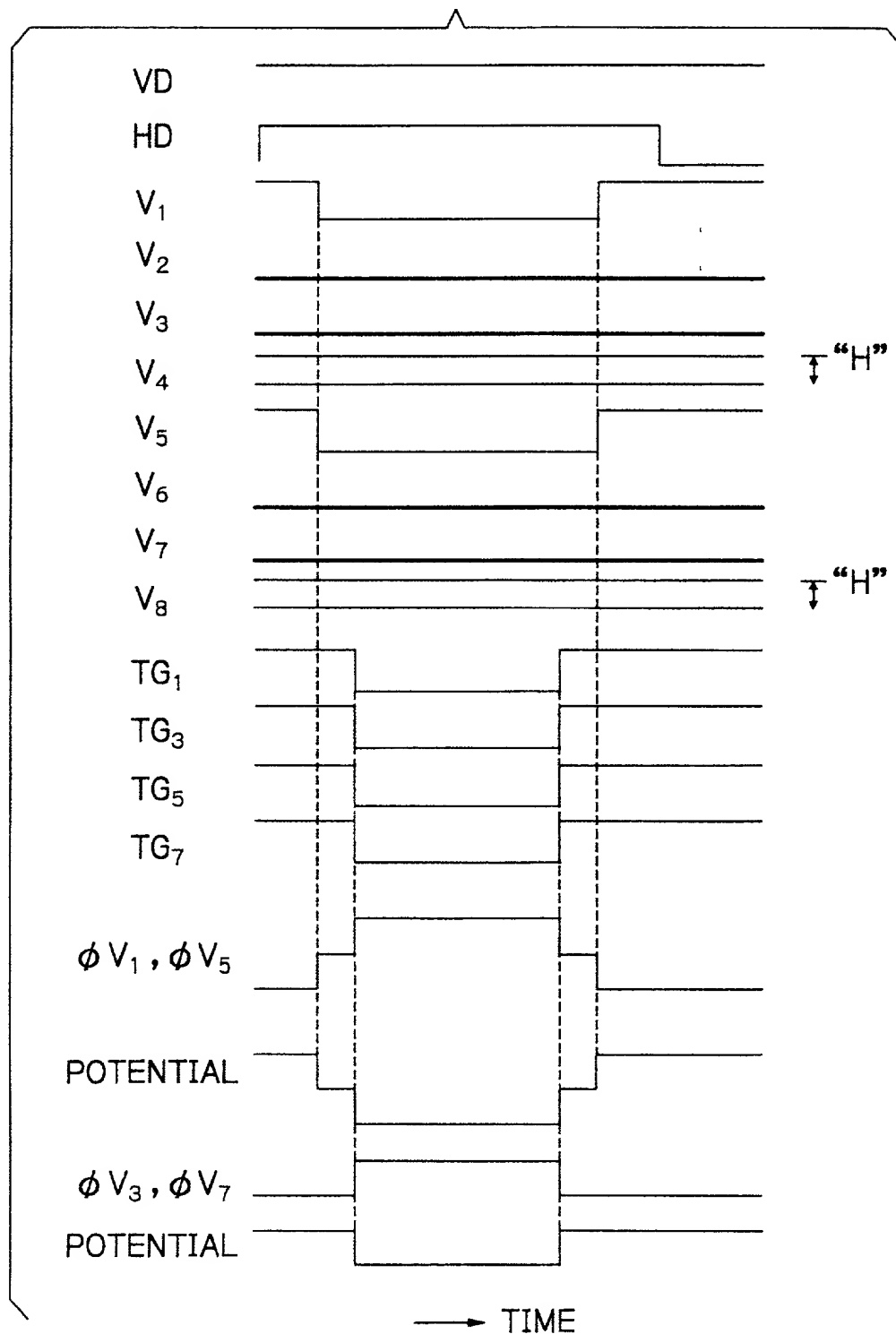
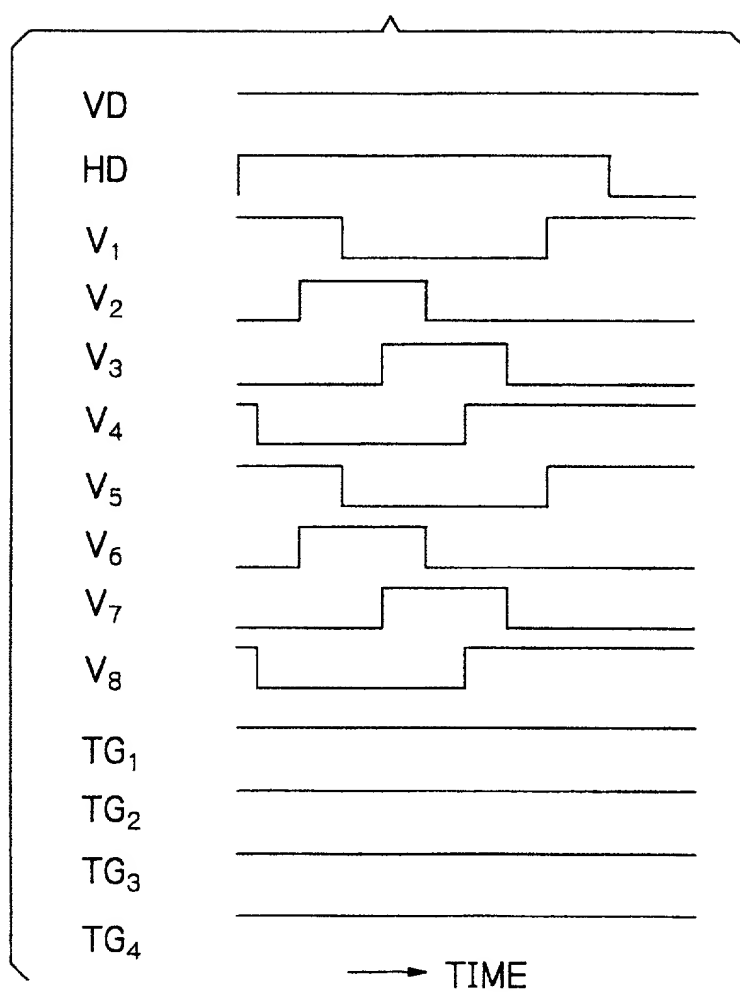


Fig. 7





*Fig. 9*

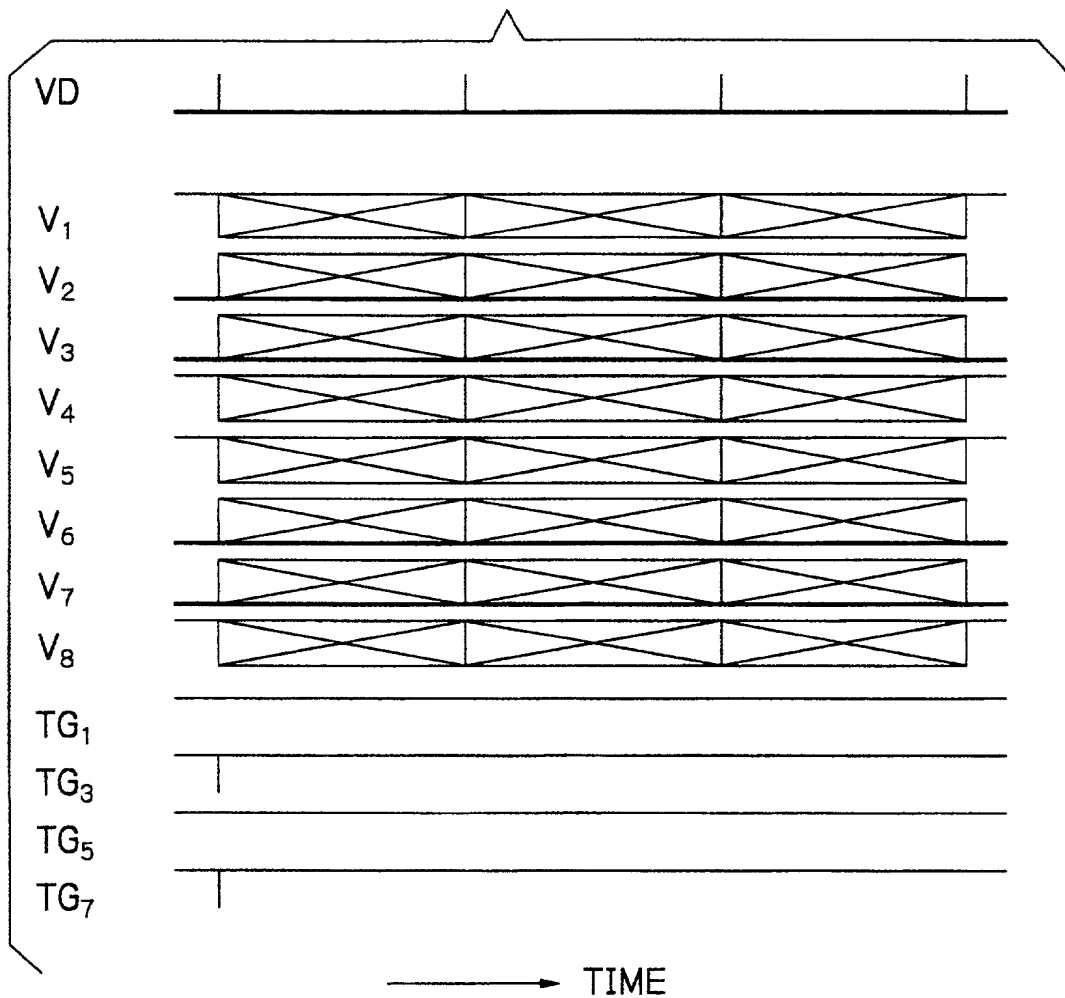
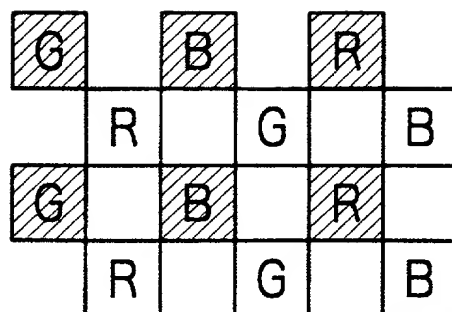


Fig. 10



TG<sub>1</sub> OFF

TG<sub>3</sub> ON

TG<sub>5</sub> OFF

TG<sub>7</sub> ON

Fig. 11A

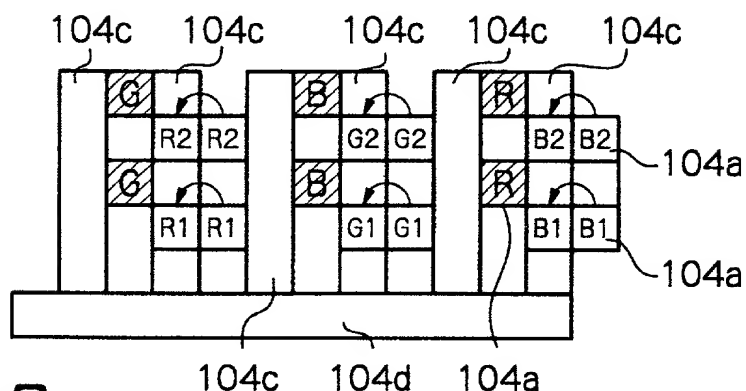


Fig. 11B

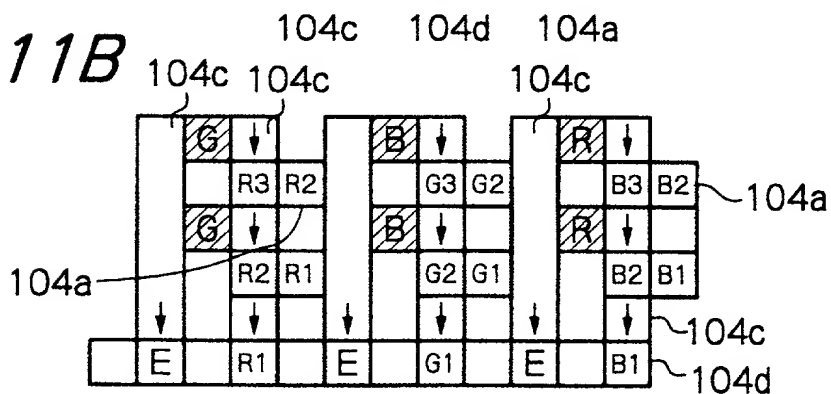
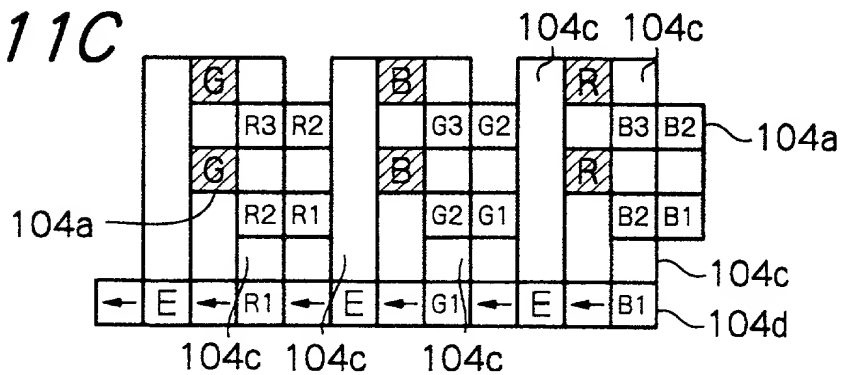
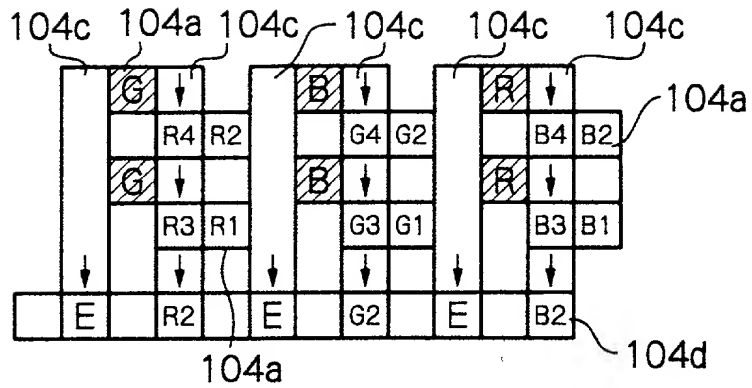


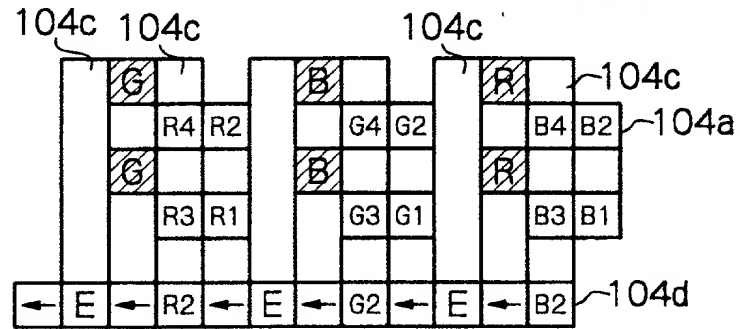
Fig. 11C



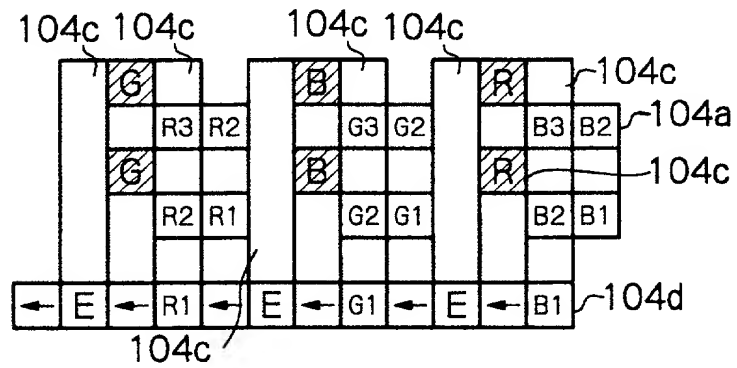
*Fig. 12A*



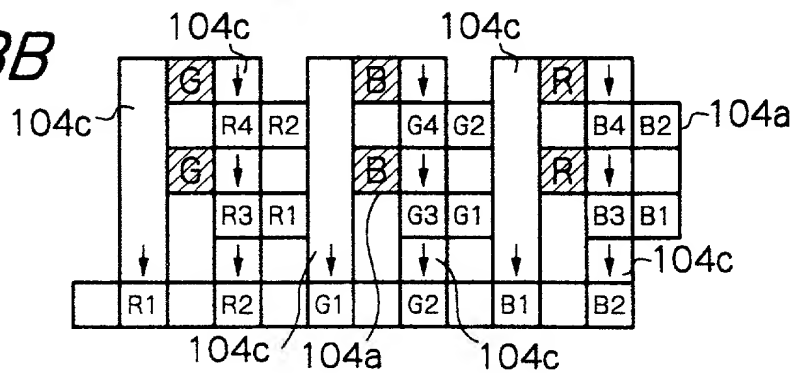
*Fig. 12B*



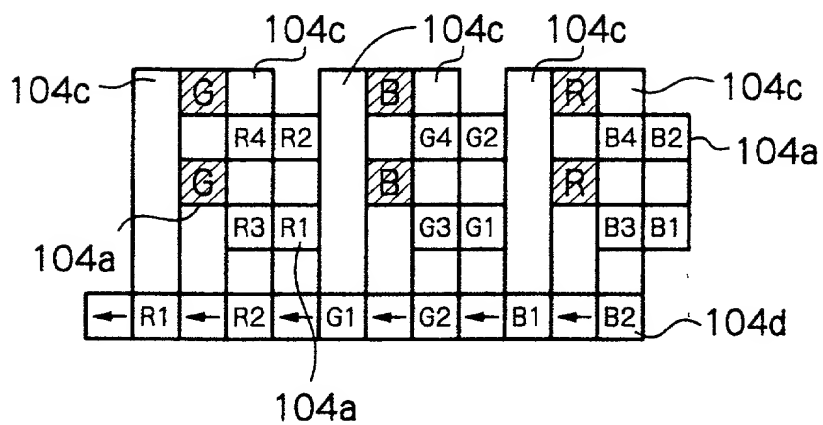
*Fig. 13A*



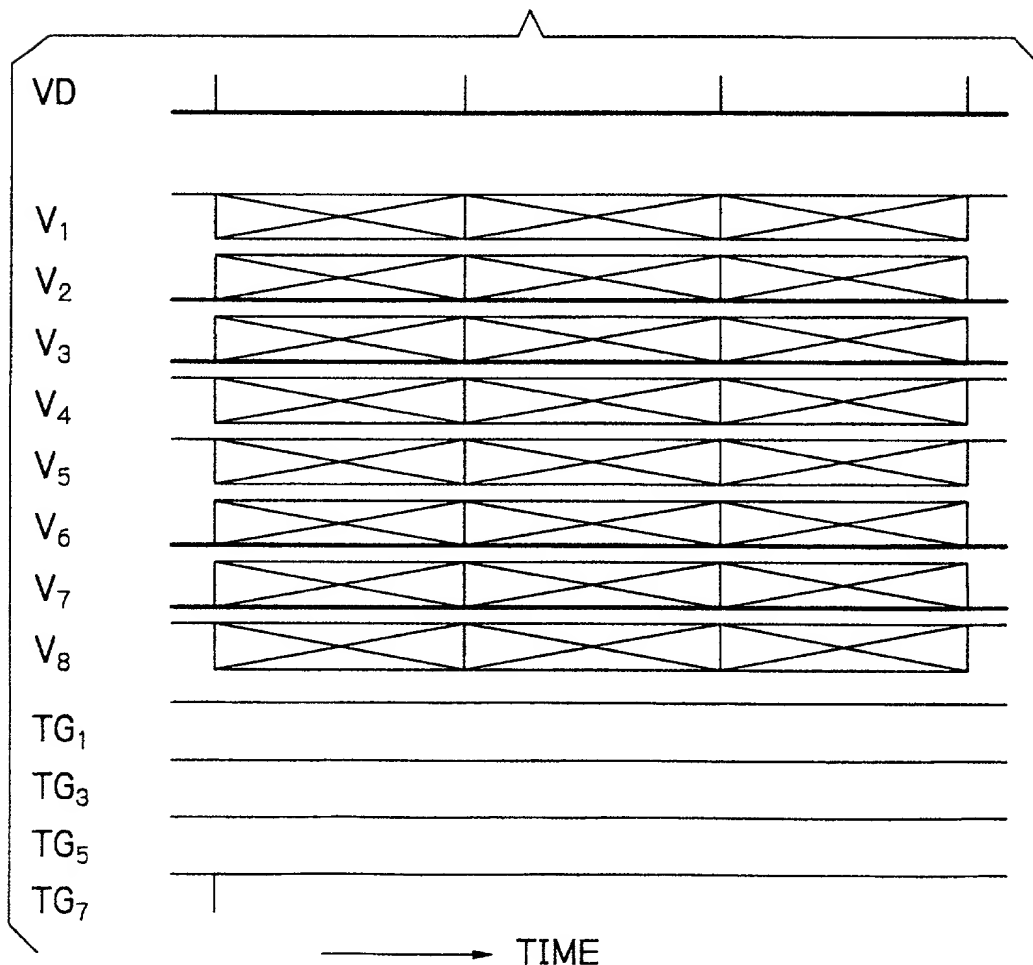
*Fig. 13B*



*Fig. 14*

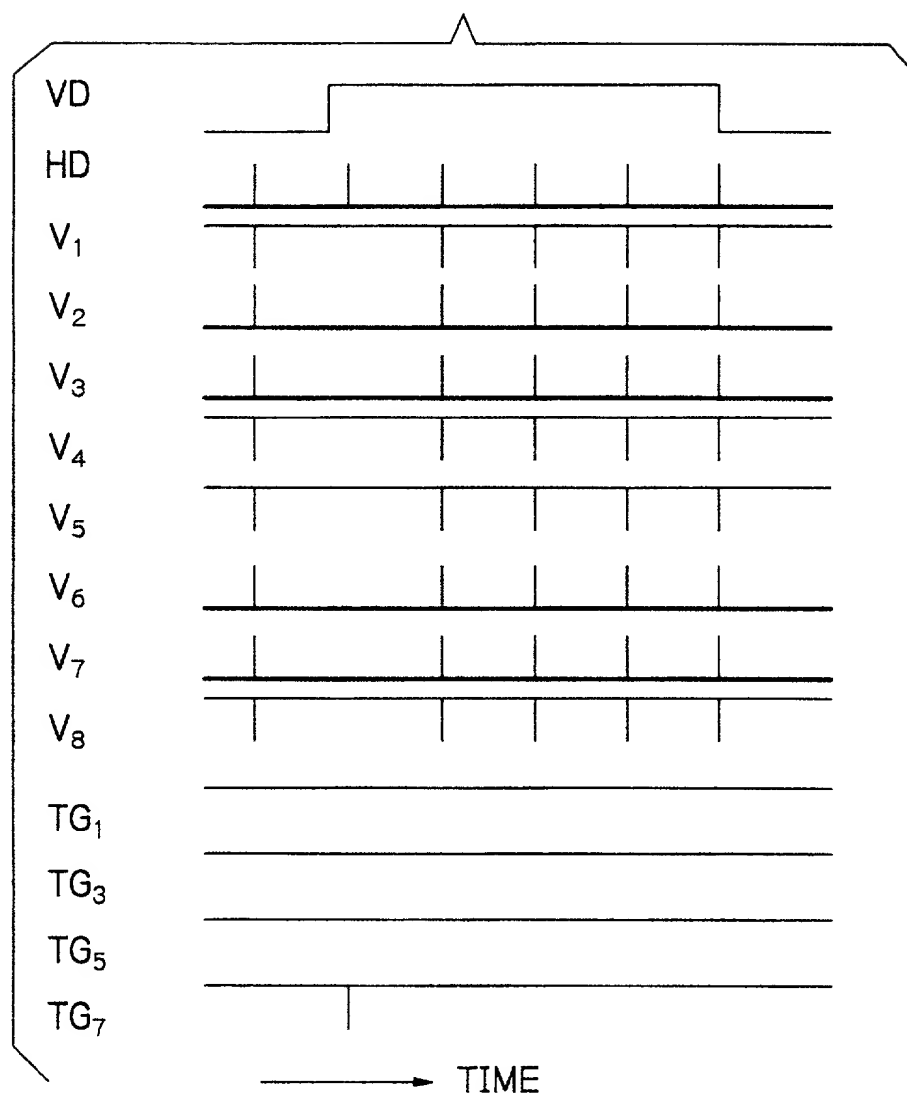


*Fig. 15*





*Fig. 16*



0949246, 012700

002210 94725750

Fig. 17

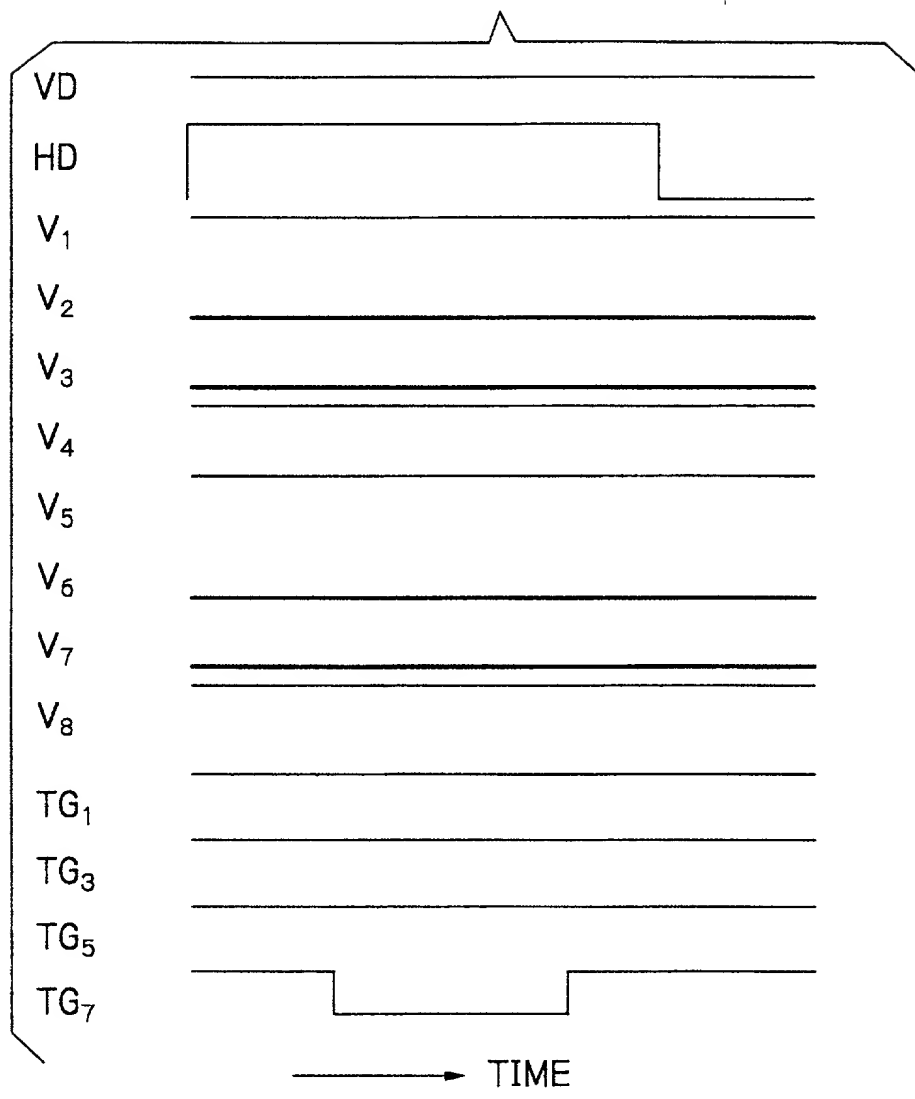


Fig. 18A

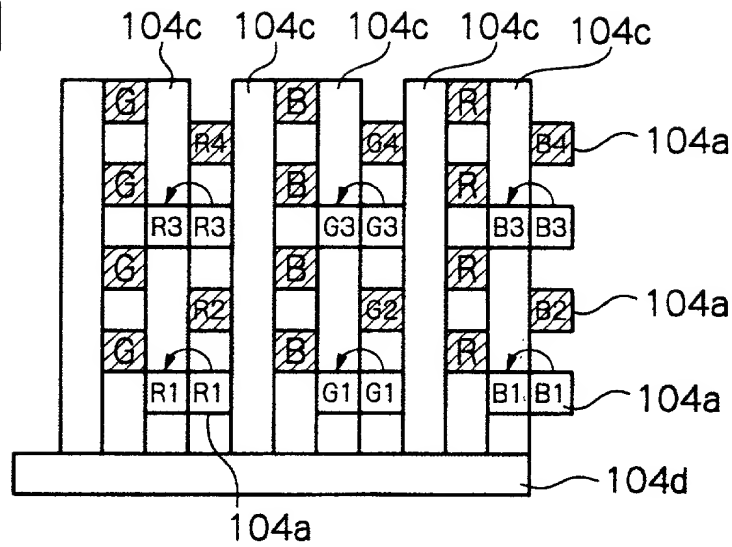


Fig. 18B

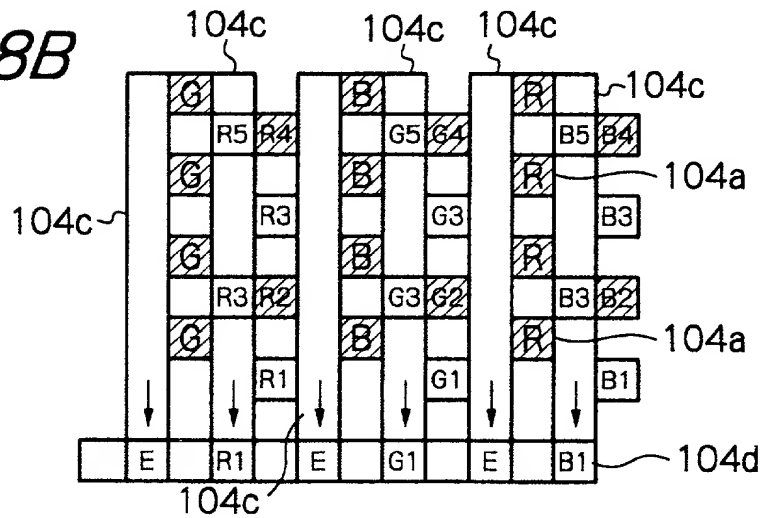
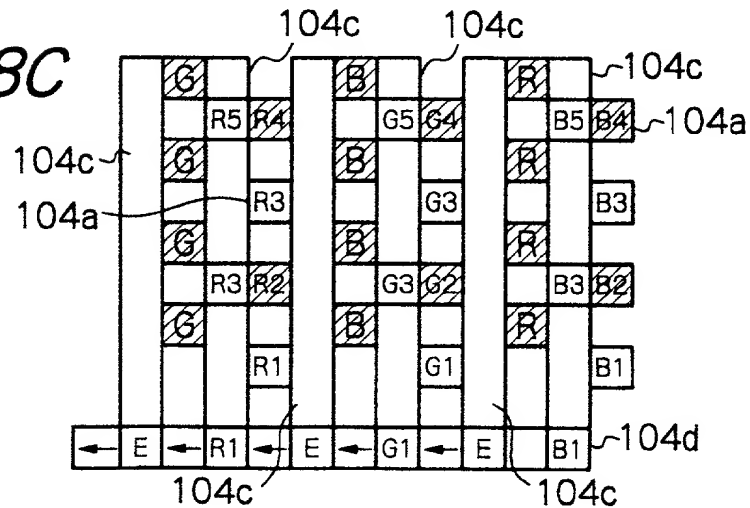


Fig. 18C



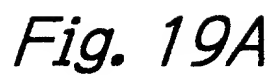


Fig. 20A

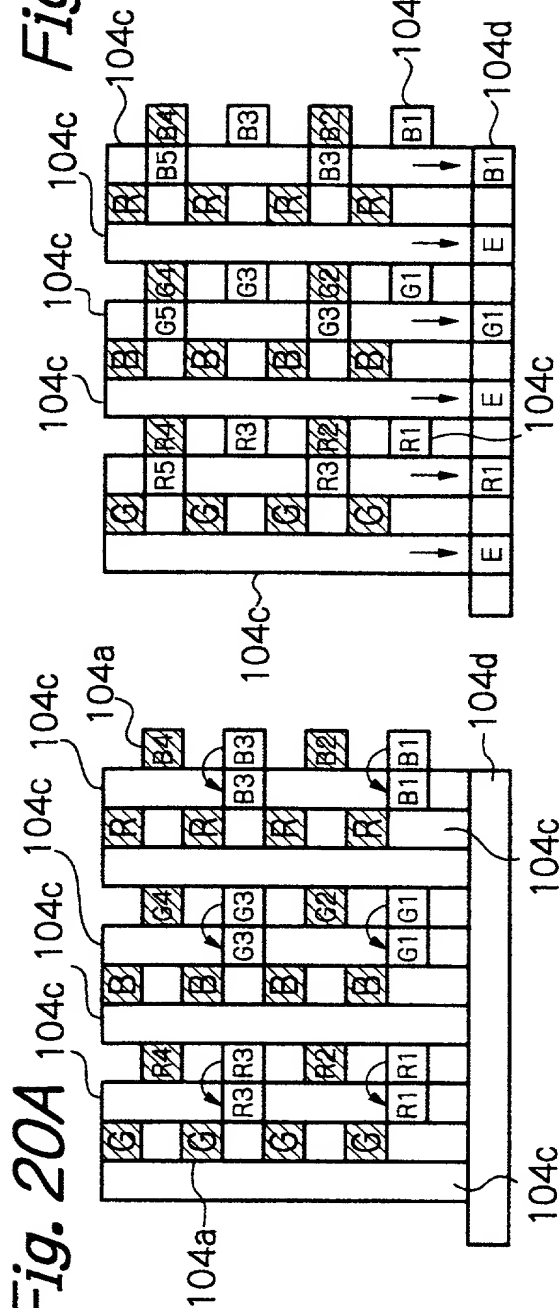


Fig. 20D

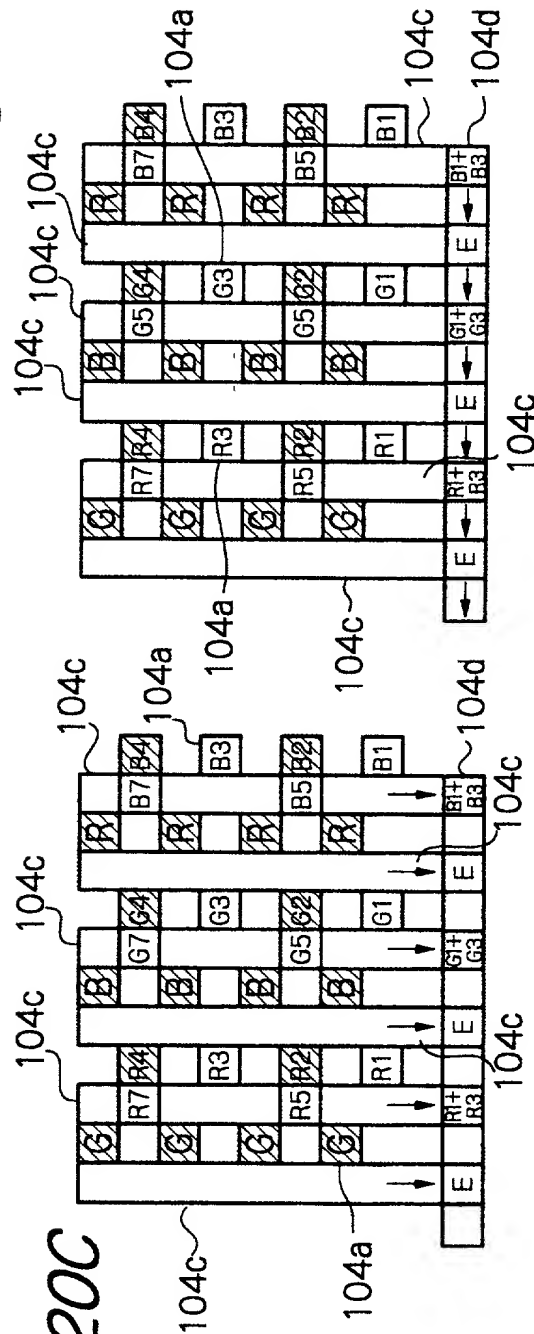
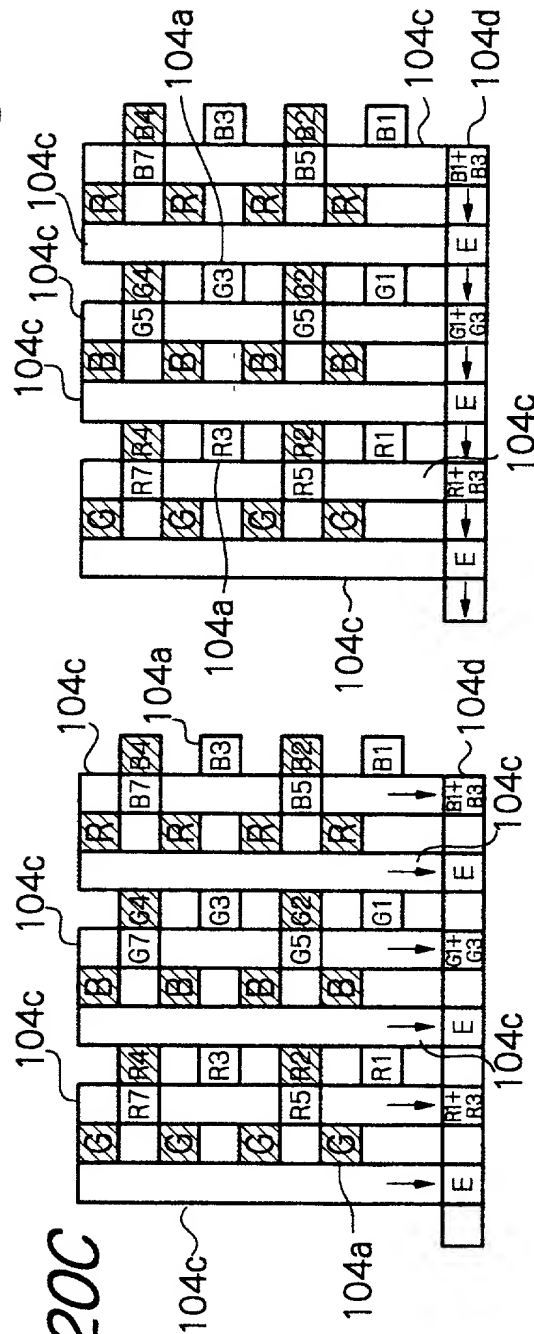
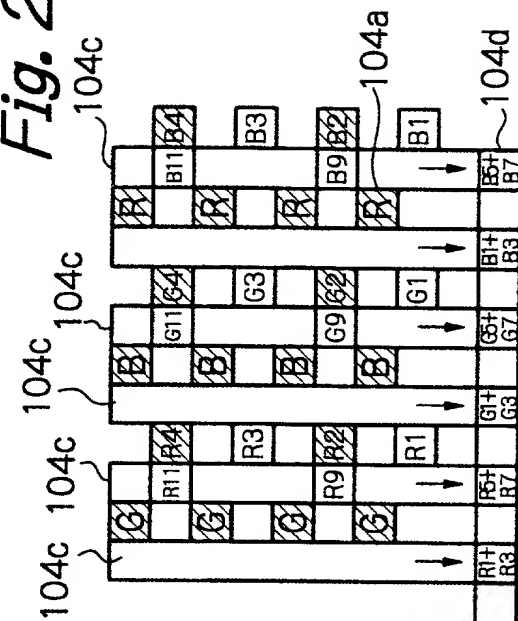


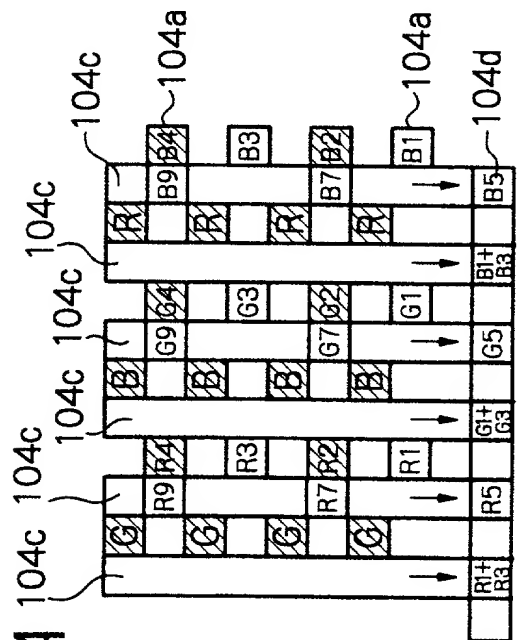
Fig. 20C



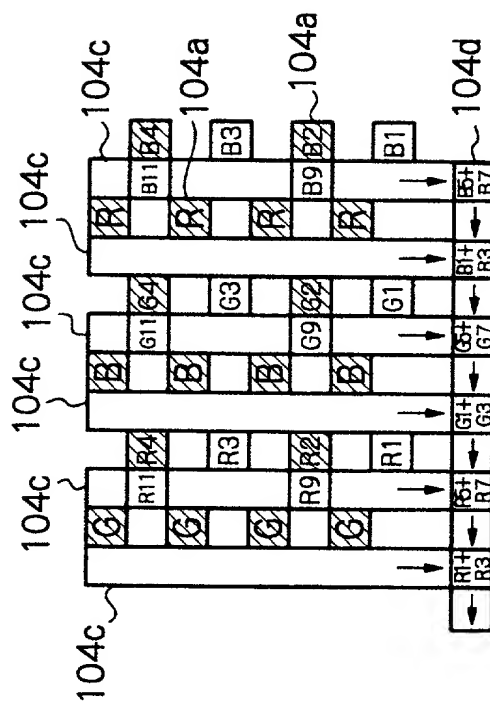
**Fig. 21B**



**Fig. 21A**



**Fig. 21C**



## BIRCH, STEWART, KOLASCH &amp; BIRCH, LLP

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378-365P

## FOR PATENT AND DESIGN APPLICATIONS

As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated next to my name; that I verily believe that I am the original, first and sole inventor (if only one inventor is named below) or an original, first and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Insert Title:

**SOLID-STATE IMAGE PICKUP APPARATUS WITH FAST PHOTOMETRY  
WITH PIXELS INCREASED, AND SIGNAL READING OUT METHOD  
THEREFOR**

Fill in Appropriate  
Information -  
For Use Without  
Specification  
Attached:

the specification of which is attached hereto. If not attached hereto,

the specification was filed on \_\_\_\_\_ as  
United States Application Number \_\_\_\_\_; and /or

the specification was filed on \_\_\_\_\_ as PCT  
International Application Number \_\_\_\_\_; and was  
amended under PCT Article 19 on \_\_\_\_\_ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I do not know and do not believe the same was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (six months for designs) prior to this application, and that no application for patent or inventor's certificate on this invention has been filed in any country foreign to the United States of America prior to this application by me or my legal representatives or assigns, except as follows.

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Insert Priority  
Information:  
(if appropriate)

Prior Foreign Application(s)  
20068/1999

Japan

January 28, 1999

Priority Claimed

(Number)	(Country)	(Month/Day/Year Filed)	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No
(Number)	(Country)	(Month/Day/Year Filed)	<input type="checkbox"/> Yes	<input type="checkbox"/> No
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(Number)	(Country)	(Month/Day/Year Filed)	<input type="checkbox"/> Yes	<input type="checkbox"/> No

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below.

Insert Provisional  
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(if any)

(Application Number)	(Filing Date)
(Application Number)	(Filing Date)

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I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

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Application(s):  
(if any)

(Application Number)	(Filing Date)	(Status - patented, pending, abandoned)
(Application Number)	(Filing Date)	(Status - patented, pending, abandoned)

I hereby appoint the following attorneys to prosecute this application and/or an international application based on this application and to transact all business in the Patent and Trademark Office connected therewith and in connection with the resulting patent based on instructions received from the entity who first sent the application papers to the attorneys identified below, unless the inventor(s) or assignee provides said attorneys with a written notice to the contrary:

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Joseph A. Kolasch	(Reg. No. 22,463)	James M. Slattery	(Reg. No. 28,380)
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C. Joseph Faraci	(Reg. No. 32,350)	Donald J. Daley	(Reg. No. 34,313)

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Inventor:  
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Insert Date This  
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Inventor, if any:

see above

Full Name of Third  
Inventor, if any

see above

Full Name of Fourth  
Inventor, if any

see above

Full Name of Fifth  
Inventor, if any

see above

GIVEN NAME	FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
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Residence (City, State & Country)		CITIZENSHIP	
Asaka-shi, Saitama, Japan		Japanese	
POST OFFICE ADDRESS (Complete Street Address including City, State & Country)			
c/o Fuji Photo Film Co., Ltd., 11-46, Senzui 3-chome, Asaka-shi, Saitama, Japan			
GIVEN NAME	FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
Residence (City, State & Country)		CITIZENSHIP	
POST OFFICE ADDRESS (Complete Street Address including City, State & Country)			
GIVEN NAME	FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
Residence (City, State & Country)		CITIZENSHIP	
POST OFFICE ADDRESS (Complete Street Address including City, State & Country)			
GIVEN NAME	FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
Residence (City, State & Country)		CITIZENSHIP	
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GIVEN NAME	FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
Residence (City, State & Country)		CITIZENSHIP	
POST OFFICE ADDRESS (Complete Street Address including City, State & Country)			

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